Crop Diversification Centre South

Annual Report 2005

Crop Diversification Centre South
Brooks Alberta

Alberta
AGRICULTURE, FOOD AND RURAL DEVELOPMENT

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Entomology Program

S. Meers, Program Leader

Field schools

In 2005 the Pest Risk Management Specialist provided entomological support to the planning and instruction at the Southern Alberta Diagnostic Field School at Lethbridge. The field school was highly successful. In southern Alberta the target crops were barley, canola and pulse crops. The entomology section received very good ratings in the evaluation that was carried out the field school. Participants really enjoyed the hands on aspect of the entomology section.

Extension support

Twenty-two presentations were prepared and given in response to requests for information or skill development related to insect concerns in crops. More than 1500 participants attended these meetings. These meetings included the Southern Alberta Conservation Association Conference at Lethbridge, Agronomy Update in Red Deer and the Irrigated Crop Production Update in Lethbridge.

The development of a dynamic pest risk predictions system is was put into use in cooperation with PFRA and the other prairie provinces. The system updated risk maps for two pest species (bertha armyworm and diamond back moth) on a daily basis as new monitoring information became available.

Agronomic support and training was also provided to industry clients through one on one consultation and electronic delivery. This was provided in concert with provincial Ag-Info Center staff on entomology issues throughout Alberta. In total 7 agricultural magazines and newspapers used the Pest Risk Management Specialist as a source in their entomology articles.

Pest monitoring

Worked extensively with partners to continue development of a pest monitoring network in the province of Alberta and join this through cooperative efforts to a Western Canadian system. Eight insect species were monitored in 2005 and forecast maps (for 2006) were created for seven of these pests.

The development of a dynamic pest risk predictions system is was put into use in cooperation with PFRA and the other prairie provinces. The system updated risk maps for two pest species (bertha armyworm and diamond back moth) on a daily basis as new monitoring information became available. Problems with the diamond back moth pheromone has lead to the dropping of that insect form the 2006 system.

An extensive set of discussions was undertaken with the partners and potential new partners in the Alberta Pest Monitoring Network. The general consensus was strong support for the Alberta Pest Monitoring Network.

Masters Degree in Entomology

Defended Masters thesis and completed all requirements. Degree was granted in May 2006.

Fruit and Vegetable Research Program

C. Neeser, Program Leader
T. Pheh, Technologist
M. Webber, Technologist

The goal of the fruit and vegetable research program at CDCS is to promote the growth of a value added fruit and vegetable industry in Alberta, by providing growers and processors with knowledge that will lead to a competitive advantage through innovation.

Research covers all aspects of vegetable and fruit production, including post-harvest handling. Most of the projects involve field research, conduced at CDCS, or in some cases, on field sites provided by collaborators. The program also has access to a variety of laboratory, greenhouse and post-harvest facilities. In these projects the common thread is the objective to generate new knowledge that will allow Alberta producers to become more competitive and take advantage of new opportunities.

Collaboration is key to the program, working with researchers from universities or other government institutions allows for optimal use of resources and access to valuable expertise. Research priorities are driven by the Industry Development Sector's mission to grow the agricultural industry in Alberta. The focus is on the development of crops for new products (e.g. black currant beverages) or on the expansion of existing crops (e.g. processing carrots).

Vegetable Research

Storage of de-crowned carrots

De-crowning of carrots, removal of leaves and the top portion of carrot roots, in the field substantially reduces processing costs of dicer carrots. De-crowning is performed prior to harvest with a specially designed, tractor-mounted implement, eliminating the need for a de-crowner at the plant, which operates much more slowly and requires additional equipment to align the carrots. The principal drawback of field de-crowning is that it may reduce suitability for storage, since crowned carrots present a major entry point for disease organisms. Storage is desirable because it allows for a longer processing window. With a longer processing window the equipment costs can be kept lower and manpower needs are more balanced. To determine whether de-crowned carrots can be stored effectively, three trials were conducted to address the following objectives: 1) to evaluate the feasibility of storing crowned carrots for a period of up to 24 weeks, 2) to determine the effect of the delay between de-crowning and harvest on storage life, and 3) to compare the effectiveness of post-harvest sanitary treatments on storage life.

Dicer and slicer carrots (cv Red Core Chantenay and Eagle) were planted on site and in a commercial carrot field following standard practices. In the first trial

Eagle and Chantenay Red Core carrots were harvested at three different times (two-week intervals), with and without the crowns removed. In the second trial Chantenay Red Core carrots were de-crowned in the field on October 20 and then harvested after 1, 6, 24 and 72 hours, to measure the significance of delayed harvesting. In the third trial the effectiveness of different sanitizers to prolong storage life was tested. The products tested included Oxidate, Mertect, peroxide, chlorine and water. Storage performance was measured in terms of weight loss, disease incidence and electrolyte leakage. At the time of writing this report measurements and analyses are not yet complete.

This trial was conducted in collaboration with Dr. Ron Howard (plant pathology). Funding was provided by the Agriculture & Food Council, the Alberta Vegetable Growers (Processing) and Lucerne Foods Ltd..

Carrot variety trial

Carrot juice is in growing demand in the beverage industry and presents an opportunity in vegetable production. Cultivar selection is an important consideration in the production of carrot juice, due to varying quality characteristics and juice yield. Suitable juicing cultivars adapted to Alberta need to be identified. The objective of this study was to compare total yields and juice yields of 15 carrot cultivars suitable for commercial production.

The highest yielding cultivars were Kinbi F1, Ingot F1, and Artist F1, with respectively 122 t/ha, 112 t/ha and 103 t/ha. Whereas the three cultivars with the highest juice content were Kinbi F1, CR501, and Sugarsnax 54 with juice yields, ranging from 54 % for Kinbi F1 to 52 % for Sugarsnax 54. Quality parameters, such as sugar content, and sugar composition, have not yet been completed and will be reported at a later date.

This trial was conducted in collaboration with Dr. Darcy Driedger (Food Science Laboratory). Daehnfeldt Inc., Evergro Canada, Harris Moran co., Sakata Inc., Siegers Seeds Co., Sunseeds and Vilmorin Clause & Co supplied the carrot cultivars.

Control of nightshade in processing peas

Nightshade is a serious weed problem in processing peas, because it produces toxic berries that are difficult to separate from peas. In southern Alberta there are three annual species of nightshade that are likely to pose a problem. The most common is hairy nightshade (*Solanum sarrachoides*), followed by black nightshade (*Solanum nigrum*) and wild tomato (*Solanum triflorum*), also known as cutleaf nightshade.

Managing nightshade can be challenging because seeds germinate in several flushes throughout the growing season. New seeds are produced within 4-5 weeks, a large portion of which will remain viable in the soil for 5 to 10 years. A proactive approach is important in the management of this weed.

Previous results demonstrated that Gesagard (prometryn) provided very effective preemergence control. Unfortunately, Gesagard is not registered on peas in the United States; restrictions regarding minimum residue levels prohibit the use of this product for peas destined for the US market. US growers in the Northwest, who have to contend with the same nightshade species, rely on Pursuit (imazethapyr) for weed control. Pursuit has been shown to pose severe recropping restrictions in Southern Alberta, especially where irrigation is limited. A trial was initiated to evaluate the Pursuit persistence on irrigated

plots. A replicated trial was established in 2005 with 1x, 0.75 x, 0.5 x, and 0.25 x rates of Pursuit applied preemergence. In 2006 a bioassay will be conducted to evaluate persistence using sensitive crops.

This work was made possible through financial assistance from the Alberta Vegetable Growers (Processing) and through in kind contributions from Lucerne Foods Ltd..

Calcium fertilizer on lettuce

Calcium is the mineral nutrient most commonly deficient in modern diets. Leafy vegetables can be an excellent dietary source of calcium, and are a good alternative for individuals with a diet low in dairy products. Increasing the calcium content in leafy vegetables could further improve their nutritional value.

As part of a preliminary project on enhancing calcium content in vegetables through fertilization management, the effect of calcium concentration in a hydroponic nutrient solution on foliar concentration of calcium and yield of leaf lettuce under two temperature regimes was tested. The principal objective was to determine whether a significant increase in calcium content of lettuce could be achieved, and whether plant growth would be reduced. The experiment was set up across six growth chambers as a completely randomized split-plot design with temperature (21°C and 28°C) as the main-plot factor and calcium concentration of the nutrient solution (50, 100, 150 and 300 ppm) as the sub-plot factor.

When grown at 28°C in the solution containing 300 ppm Ca, the acid extractable Ca in fresh lettuce leaves increased from an average of 179 mg/100 g to 229 mg/100g. This was not the case when the plants were grown at 21°C. High levels of Ca in the hydroponic solution did not result in a significant yield loss compared to the treatment with the lowest Ca concentration. Under the more favourable temperature, increased calcium also resulted in increased tissue strength, as measured by the force required to cut through 3 leaves. These results suggest that calcium fortified lettuce could be produced in a hydroponic system by increasing the concentration of calcium in the nutrient solution.

This project was conducted in collaboration with Dr. Nick Savidov (Greenhouse Crops).

Fruit Research

High tunnel strawberries

High tunnels are rapidly being adopted to extend the growing season in cool climates. The principal benefits of high tunnels are derived from increased temperatures early and late in the season. It is estimated that high tunnels will protect strawberries from frost damage with overnight temperatures as low as –10°C. Further frost protection can be obtained when row covers are used in addition to the tunnel. Harvest could begin in early June and extend until late October with day neutral varieties. Since high tunnels constitute a significant expenditure ($0.70 to $1.30/sq ft), intensive production methods will have to be used to increase yield per unit area. This will involve the use of raised beds equipped with a drip line and covered with plastic. Although high tunnel strawberry production systems have been developed elsewhere, research is needed to adapt these systems to Alberta conditions.

In August of 2005 a trial was established using existing facilities at CDCS. The objective was 1) to compare the performance of promising day-neutral and June-bearing cultivars under high tunnels, and 2) to determine optimal timing of planting of plugs or bare-root plants for tunnel production. The first harvest cycle will take place in 2006.

Experiments will be conducted in two 6 m wide by 15 m long high tunnels at CDCS. The tunnels will contain 6 raised beds equipped with drip irrigation and covered in black plastic. One of the tunnels will be used for a variety trial that will include a day-neutral variety, two everbearing types (test selections from AAFC) and 3 June-bearing cultivars (L'Amour from Univ. of Guelph, St-Jean and Kent from AAFC). The remaining outer rows (one on each side) will be used as guard rows. The treatments will be randomized and replicated 4 times. Measurements will include yield (twice per week) disease incidence and fruit quality (size, firmness, brix, color).

In a second experiment fall planting vs spring planting for plugs and bare-root plants will be compared. Measurements will be the same as above.

Funding for this project was provided by the Alberta Farm Fresh Producer Association.

Antioxidants

The annual production for saskatoons and black currants is expected to range between 1-3 million pounds each.

Saskatoons and black currants have become significant fruit crops in Alberta. There are approximately 1200 acres of saskatoons and 430 acres of black currants. The annual production for saskatoons and black currants is expected to range between 1-3 million pounds each. In addition, dwarf sour cherries are likely to become another major fruit crop within the next three to four years.

As production increases marketing the crop is becoming a greater challenge. Berry producers in other provinces and in the US are increasingly promoting the health benefits of their fruit. Cranberries and blueberries are two examples where health-oriented marketing has been successful. There is no doubt that black currants, saskatoons, and dwarf sour cherries are healthy, but little scientific data is available to support more specific claims. Quantitative information on antioxidants and antioxidant activity in these crops will enable Alberta growers to market these fruits more effectively. Assessment of genetically and environmentally driven differences will allow producers and processors to select optimal varieties and locations for their orchards. Because of the perennial nature of orchards, it is important that such information is made available early in the establishment of this new agricultural industry. Data on antioxidants and antioxidant activity is also needed to justify further studies that may involve clinical trials leading toward the development of natural health products.

This project was developed in close collaboration with the Fruit Growers Society of Alberta and received financial support through the National Science and Engineering Research Council (as part of a research grant to Olds College) as well as the Alberta Professional Horticultural Congress and Foundation Society. Preliminary results from this project were presented at the Alberta Horticultural Congress on November 17, 2005. A final report with the complete analysis of the data will be released by March 2007.

Saskatoon post-harvest

Increased consumer awareness of health benefits of fresh fruit can facilitate marketing of saskatoons, which have been shown to be high in antioxidants.

Currently saskatoons are grown predominantly for the processing and U-pick markets. The retail market of fresh saskatoons has not yet been developed, in part because of poor storage performance and shelf life. A variety of post-harvest treatments, such as immersion of the fruit in chlorine or peroxide based biocides, or fumigation with acetic acid and/or steam, may significantly improve storage performance of saskatoon fruit.

The objective of this project was to test whether such treatments would indeed be beneficial. The results showed that post-harvest treatments with steam, acetic acid, and the two combined have the potential to significantly reduce weight loss of saskatoon fruit. However, fungal growth was only suppressed with acetic acid applied as steam. The strongest suppression occurred with the 20% solution of acetic acid, but at this concentration there was also severe moisture loss. The best compromise appeared to be the 10% acetic acid solution applied as steam; it still provided some fungal control and was among the best treatments to reduce moisture loss.

Black currant cultivars

Numerous black currant cultivars have been developed in various European countries. Growing conditions in Europe tend to be quite different from Alberta. Adaptation trials are required to determine the most suitable cultivars.

In May 2003, a trial with nine Russian cultivars, not previously tested under Alberta conditions, was established. Four of the nine cultivars tested showed excellent hardiness, good resistance to white pine blister rust and rapid growth. Disease incidence in 2005, was much less than the previous year. There were also important yield differences between cultivars, but these were largely determined by differential frost damage during flowering.

We thank McGinnis Berry Crops Ltd. for providing the black currant plants for this trial.

Strawberry cultivar testing

In Alberta strawberries are a very important crop to a large number of U-pick operations. Further expansion of this industry will most likely be driven by new production technologies, like the high tunnel project. This led to the conclusion of the conventional matted-row strawberry cultivar trials with the 2005 season. A final report summarizing the data collected from 2002 to 2005 will be made available later this year.

The collaboration of Dr. Sharokh Kanizadeh, strawberry breeder at the AAFC - St-Jean sur Richelieu, Qc, is gratefully acknowledged.

Technology Transfer

Extension activities included a Alberta Organic Producer Association field day at Orchard Palace (Two Hills), a workshop for vegetable growers in Lethbridge, presentations at the Alberta Black Currant Network meeting, at the Alberta Vegetable Growers (Processing) annual meeting, at the Berry School organized jointly by the Alberta Fruit Growers Association and the Alberta Farm Fresh Producers Association, at a fruit production workshop in Two-Hills, at the Alberta Horticultural Congress, and on two occasions at Olds College. Contributions were also made to newsletters of the Alberta Farm Fresh Producers Association, the Fruit Growers Society of Alberta, the Prairie Fruit Journal and the Alberta Vegetable Growers (Processing).

Grass Seed and Forage Crops Program

H. Najda, Program Leader
A. Kruger, Technologist

The grass seed and forage crops program conducts agronomic and adaptability research to develop and provide information on grass and legume seed production, and on traditional and new forage crops.

The following industry partners and institutions sponsored various research projects in 2005: Alberta Branch Canadian Seed Growers Association; Association of Alberta Co-op Seed Cleaning Plants Ltd., Alberta Research Council – Vegreville; AgricoreUnited (AB); Agriculture & Agri-Food Canada; Barenbrug USA, Inc. (Oregon, USA); Boreal Plant Breeding (Finland); Brett-Young Seeds (MB); Deutsche Saatveredelung (Germany); DLF-Trifolium (Denmark); John Zuelzer & Son Canada Ltd. (BC); Miller Seeds (AB); Moore Seed Processors (AB); Newfield Seeds Co. Inc.(SK); Northstar Seed Ltd. (MB); Peace Pedigreed Seed (AB); Peace River Seed Co-op Ltd. (AB); Pickseed Canada (ON); Pioneer Hi-Bred Ltd. (ON); Prairie Seeds Ltd. (AB); The Scotts Co. (Oregon, USA); SW Seed Canada Ltd. (SK); Tomorrow's Seed (BC) and Turf-Seed, Inc. (Oregon, USA).

Grass and annual legume seed production studies

Perennial grass seed production has become a major area of research in southern Alberta. Many seed companies from Canada, the United States and Europe are now contracting production acres in southern Alberta under irrigation and rainfed areas throughout the province.

In 1998 the Western Grass Seed Testing Program (WGST) was initiated to provide seed yield and adaptability information to the seed industry. The trials are a cooperative effort of federal and western provincial research and extension staff and the seed industry. Testing sites are located at Fort St. John in BC; Beaverlodge, Bow Island, Brooks and Vegreville in AB; Melfort and Saskatoon in SK and Arborg and Portage La Prairie in MB.
Species currently being tested include Kentucky bluegrass, smooth bromegrass, chewings and creeping red fescue, hard, blue hard, meadow and tall fescue, orchardgrass, perennial ryegrass, timothy and some native species. Results of this program have contributed to increased contract seed production not only in southern Alberta but the rest of the province and Western Canada especially of newer grass species such as tall fescue, perennial ryegrass, Kentucky bluegrass and meadow bromegrass.

The grass seed and forage crops program at CDCS is responsible for seed acquisition and distribution to test cooperators and the production of an annual report for both seed producers and the seed trade.

In 2004, a three-year cooperative project with Dr. S. Acharya with AAFC in Lethbridge and Dr. J. King of the U of A in Edmonton was initiated to evaluate annual legume species as potential seed crops in Alberta. The project is funded through the Alberta Crop Industry Development Fund (ACIDF) and there are four project sites. Three irrigated sites are located in southern Alberta; CDCS substation Bow Island, CDCS, Brooks and AAFC - Lethbridge. A rainfed site is located at the U of A in Edmonton.

Annual legume species being evaluated include berseem, rose, Persian, arrowleaf, crimson clover and hairy vetch. Second year results continued to indicate the strong potential of crimson clover, rose clover and woolypod vetch as seed crops especially under irrigation in southern Alberta. Yields at Bow Island and Brooks were encouraging with average seed yields for crimson clover yielding over 925 and 1000 kg ha^{-1}, respectively. Rose clover had average seed yields over two years of 950 kg ha^{-1} at Bow Island and 860 kg ha^{-1} at Brooks.

Annual legume yields at Bow Island and Brooks were encouraging with average seed yields for crimson clover yielding over 925 and 1000 kg ha^{-1}, respectively. Rose clover had average seed yields over two years of 950 kg ha^{-1} at Bow Island and 860 kg ha^{-1} at Brooks.

Western forage testing program

The Western Forage Testing Program (WFT) began in 1995. This is a cooperative tri-province (AB, SK and MB) venture that tests experimental forage cultivars for registration purposes. In most cases, enough location years are incorporated into the testing program to provide a basis for registration and to provide data for particular agro-climatic areas.

The grass seed and forage crops program at CDCS is responsible for seed acquisition and distribution to test cooperators and the production of an annual report for both seed producers and the seed trade.

Information from this program is used to annually update the Agrifax pamphletVarieties of Perennial Hay and Pasture Crops for Alberta, Agdex 120/32.

In 2005, program focus began to shift to new crops for bio-industrial uses to align more closely with the Alberta Agriculture, Food and Rural Development's growth strategy. New projects are being developed to evaluate traditional and new crops for fiber and energy use and for use in the cosmetic and personal ingredients industries.

Technology Transfer

The program leader, H. Najda, provides information services to growers, industry personnel, producer and commodity organizations and other AAFRD staff. In 2005, presentations were made at several industry and producer meetings and provincial advisory committees. Two information pamphlets on forage variety performance and information on the Ropin' the Web site were updated. The program leader wrote several magazine articles.

The program leader participated on the Alberta Forage Variety Committee, the Western Grass Seed Testing Committee, the Western Forage Testing Committee, and the board of directors of the Chinook Applied Research Association.

Greenhouse Crops Program

N. Savidov, Program Leader
P. Cote, Technician

The mandate of the Program is to grow the greenhouse vegetable industry through industry partnerships in applied research projects focused on market opportunities.

To do this the program has focused on the following projects:

- Increasing crop production and reducing costs through the use of coconut coir as an alternative to sawdust as a growing substrate.
- Project in collaboration with Red Hat Co-op, AGGA and ACIDF.
- Research on new biocontrol agents to decrease crop losses from pests and diseases with University of Alberta and Plant Pathology Program, AAFRD
- Developing technologies for production of high value crops in confined environment (bio-actives, phytopharma, organics)
- Introduction of new greenhouse vegetables crops like green vegetables to capture domestic market
- Introducing recycling technologies such as development of soil amendment from greenhouse substrate waste and recirculation of nutrient solution
- Evaluation of CO_2 applications (concentration, placement) on greenhouse crop yield
- Leading the NIF project ,"Evaluation and development of aquaponic production in AB."
- Discovery research on the effect of complex plant growth factor from organic recirculation system (aquaponics) on hydroponically grown plants

Industry Support

Red Hat Cooperative Ltd., Alberta Greenhouse Growers Association, Alberta Aquaculture Association, Alberta Research Council, Alfalfa Mills Ltd., Bear River Zeolites, Canada, Air Liquide Canada Inc., Millenniumsoil Coir, Lyalta Greenhouses, Western Argus Control Systems Ltd., Seair, VG International, MDM Aquafarms, Circle M Trout Farm, Klok Feeds, Newlywed Foods (An Edmonton Nutraceutical Company), ECA Solutions, Koppert.

Support from various funding and academic institutions:
Alberta Crop Industry Development Fund, ACIDF, Diversified Livestock Fund of Alberta, DLFOA, New Initiative Fund, NIF/IDS, AAFRD, Aquaculture Collaborative Research and Development Program, Fisheries and Ocean's Canada, ACRDP-DFO, University of Alberta

Selection of alternative substrates for production of greenhouse vegetables in Alberta

This work is a result of comprehensive four-year study on greenhouse substrates conducted at CDC South, Brooks, Alberta. The project started in 2003.

Experiments with greenhouse substrates

Neutral substrates used in soilless culture can remarkably differ in their physical properties affecting air content and retained volume of available water. These differences should be taken into consideration when growing greenhouse crops with varying demands for water and oxygen in root zone.

Sawdust has been a standard medium for greenhouse industry in Alberta for several decades due to its low price and relatively high productivity. However, sawdust is prone to gradual decomposition which leads to unfavorable physical properties of the substrate converting it from "dry" into a "wet" substrate with higher volume of retained water and oxygen deficiency. Coir, more resistant to degradation, contains 2-3 times more lignin, which is a highly stable polyphenolic compound. Rockwool and perlite are not degraded by microorganisms because of their mineral nature. However, these substrates are more expensive. The high environmental cost of inorganic substrates disposal is another issue. Whereas, recycling of organic substrates in agriculture and land reclamation can be easily achieved.

In spite the higher stability of perlite, there was no improvement in productivity of either bell pepper or long English cucumbers when using perlite (Westgro) as a greenhouse substrate compared to sawdust. There was a 9.7% yield decrease of spring variety of Sabrina cucumber, in 2001/2002. In 2002/2003 there was a 10.3% decrease of spring crop yield and 9.9% decrease of summer crop yield. Bell pepper is better adapted to "dry" substrates so the negative effect of perlite on the pepper crop was less evident.

Bell pepper showed varietal differences in response to coir. Some encouraging results were seen when coconut fiber was used for orange pepper production in 2002/2003 and 2003/2004, but there a consistently negative effect for Sardana yellow pepper those same years. Red peppers had both positive and negative responses. Changing physical properties of coir by increasing size of the particles, will increase air volume and make it more appropriate for bell pepper production.

There was no negative effect of coir on production of long English cucumbers observed during all three years of the trials. Production of fall crop on coir increased yield by 11.9% and 12.4% compared to sawdust in 2002/2003 and 2003/2004 respectively. With a flatter water retention curve, compared to sawdust, coir appears to be the most appropriate substrate for long English cucumber.

Rockwool was used in 2003/2004 and showed a superior quality as a greenhouse substrate for most treatments and all three greenhouse crops, the exception of Sardana yellow pepper. Sardana responded negatively as it did with coir. Sardana yield decreased by 19.8% and 22.7%

Experiments with zeolite

Zeolites are a group of naturally occurring minerals with physical and physicochemical properties allowing their applications in such diverse areas as construction and agriculture. They are capable of adsorbing part of the excess of nutrients, thus resulting in more balanced macronutrient cation ratios in the root environment. Four years of experiments with zeolite amendments showed a positive effect of zeolite mixtures on all three greenhouse crops. This effect depended on crop, variety, zeolite content in grow bags, source of zeolite, environmental conditions (with and without CO_2), and type of substrate. Negative effects of zeolite were observed on some of the crops under certain conditions.

The nature of used substrate strongly determined the effect of zeolite. Sawdust-zeolite mixtures showed most consistent effect on bell pepper production increasing yields by 5%-20%. The effect of zeolite amendments to perlite and coir on pepper productivity was less consistent. Perlite-zeolite mixtures were beneficial only in 8 treatments out of total 18 treatments. Coir-zeolite mixtures improved yield in only 3 out of 12 treatments. Perlite-zeolite mixture (20% zeolite) increased yield of yellow pepper variety, cv. Bossanova, by 41% in 2001/2002 and coir-zeolite mixture increased yield of orange variety, cv. Sympathy, by 30.1% in 2002/2003. Both treatments included enriched CO_2. Increasing zeolite content in the growing medium to 40% did not lead to yield increase.

Sawdust-zeolite mixtures showed most consistent effect on bell pepper production increasing yields by 5%-20%.

Excessive application of zeolites pushing buffering capacity of the neutral substrate too high benefited neither peppers or cucumbers. The yields were decreased by 13.9% and 14.5% with zeolite #2 in mixtures with coir when cucumbers were grown without and with supplemental CO_2 respectively compared to pure coir. The buffering capacity of coir might have apparently aggravated the negative effect of zeolite on productivity of cucumbers in this case.

Only one year of study has not provided conclusive evidence of the positive effect of zeolite on tomato production. A trend of yield increase was noted though when10% zeolite was added to sawdust and coir.

The ositive effect of zeolite on greenhouse crops may be explained because nutrients are retained during the day feeding period and gradually released at night. Another explanation may be the high water retaining capacity of zeolite, which may be beneficial for mixtures of zeolite with "dry" substrates like sawdust and perlite. In this case, zeolite benefits will be less evident for mixtures of zeolite with "wet" substrates. The effect of other factors such as mineral composition of zeolite on crop productivity cannot be ruled out. Therefore, the precise mechanism of zeolite effect on greenhouse crops requires further investigation.

Four years of test trials with zeolites allowed accumulating unique information about effect of zeolites on major greenhouse vegetable crops. Zeolite amendments to sawdust produced most consistent positive effect. The use of zeolite with perlite and coir should be considered in combination with a specific crop response, which can vary depending on environmental factors, such as CO_2 level and genetic factor.

Effect of substrate on plant recovery from acidity stress

Beefsteak tomato plants grown on substrates with different buffering capacities were subjected to 8 hours of acidity stress. It appears that as low as 10% zeolite in the substrate with moderate 99 meq CEC can provide plants with an effective protection during short period of severe stress. The best result was achieved for combination coir-zeolite where almost 100% of the tomato plants recovered day two after the stress event. Pure coir was also effective. However, the same level of recovery was achieved on day seven after the event. No yield data was collected from the plants.

Secondary use of spent greenhouse substrates

Every year the growers in Alberta have to pay for the disposal of thousands bags of used substrates. There is an environmental concern also when dumping large amount of waste every year. A cost-effective proces to convert used growing media into a commercial product that could be marketed as a high quality topsoil and soil conditioner could resolve these issues. As an added bonus there could be an additional revenue source from direct product sales.

Spent greenhouse substrate created better conditions for the root development of nursery crops than a standard mixture used in the industry. As a result, the productivity of *Ribes alpinum,* an ornamental shrub popular in North America, increased more than 2 times in some of the treatments when using spent greenhouse substrates. Spent coir-based mixtures were more effective than spent sawdust-based mixtures. There was an increase in productivity compared to the standard medium based on bark, peat, and sand in both cases. The combination of sawdust-zeolite was beneficial, although the yield increase was minor compared to pure sawdust, yield was improved by 4.2%. There was no positive effect observed when spent sawdust/zeolite-containing substrates were used in combination with peat and sand. Combination of zeolite and coir was not beneficial for the shrub production. Coir-zeolite mixture led to 12.1% decrease in productivity of *Ribes alpinum* compared to pure coir, which confirmed many observations in experiments with greenhouse crops.

Developing a commercial soil conditioner from greenhouse organic waste

Technical feasibility of land application of spent coconut coir has been proven in a series of greenhouse trials at CDCS and ARC, Inc. The amendment of a loamy chernozemic Ap horizon with spent coconut coir in the amount equivalent to approx. 600 m^3 per ha has increased the dry biomass of barley and Jerusalem artichoke significantly. In contaminated soil, the coconut coir amendment has increased the biomass of barley by one third and almost doubled it in artichoke; eliminating completely the contamination effect on both crops and improving soil characteristics.

The zeolite addition has not interacted consistently with the coir effect on soil and plants in this study. Both did increase the artichoke height in the non-contaminated soil and decreased artichoke biomass in contaminated soil. This cannot be explained.

A greater benefit of zeolite application can be expected on soils with low cation exchange capacity (CEC) such as sandy soils. The same benefit is expected with used coconut coir, which also have buffering capacity. Another advantage of used coconut coir is that it can demonstrate a greater effect of residual nutrients, which remain in coir medium after the greenhouse production cycle.

On soils with no obvious nutrient deficit and with adequate CEC, spent coir processing prior to land application could be limited to the removal of the slab polyethylene cover, drying, fumigating, and possibly pelletizing. On other soils, plants may respond to application of coir mixed with zeolite and, possibly, fertilizer including alfalfa pellets.

The study has to move to a field trial to demonstrate the benefits of commercial application.

Improved management of root and stem rot diseases in greenhouse cucumber

This project is conducted in collaboration with the plant pathology program at CDCS. Please visit that section of this report for more information.

Evaluation and development of aquaponics production and market capabilities in Alberta

This project was conducted in collaboration with aquaculture program, AAFRD.

An aquaponic system was built, based on the University of Virgin Islands design, as a prototype for commercialization in Alberta, Canada in 2002. To test commercial feasibility of aquaponics under the climatic conditions of Alberta the food fish tilapia was selected in combination with several conventional greenhouse plants (cucumber, tomato, etc.), herbs, medicinal plants, and nutraceutical plants.

During the third year, the major focus of the project was on production and market evaluation of Genovese basil as high value crop. Six other crops (cucumber, tomato, basil, rosemary, *Echinacea* and lettuce) were grown in aquaponic and hydroponic nutrient solutions in greenhouse experiments using raft hydroponics.

Aquaponic nutrient solution (ANS) was obtained from a commercial-scale aquaponics system for the combined culture of tilapia and hydroponic plants. Water in the recirculating aquaponic system was used continuously for nearly 2 years with minor daily exchange (<1%) to replace water lost during solids removal.

Hydroponic nutrient solution (HNS) was prepared to match the macro- and micro-nutrient concentrations of ANS with the exception of lettuce where HNS was prepared by following a recommended formulation.

Plants were grown for 1 to 3 months depending on plant type.

Aquaponically produced plants attained a higher relative growth rate for both roots and shoots compared to plants grown hydroponically under non-limiting nutrient conditions.

Root biomass was especially affected. Rosemary plants attained significantly greater height (35 vs. 31 cm), shoot weight (226 vs. 141 g) and root weight (290 vs. 141 g) in ANS compared to HNS. Nutrients were depleted faster in ANS than in HNS in the beginning of the experiments. If plants were allowed to grow until the nutrients solutions became depleted, the final plant biomass in HNS caught up to the final plant biomass in ANS. There was no significant difference in the phenols accumulation between aquaponically and hydroponically grown plants. However, the phenols yield was significantly higher for aquaponically grown plants since they produced considerably higher leaf biomass.

This study indicates that there is a factor stimulating nutrient uptake and assimilation by plants grown in aquaponic solutions where nutrients and many organic compounds are derived from fish feed. It is hypothesized that plant growth promotion (PGP) results from the interaction of nutrients, organic compounds and bacteria. Further research is needed to identify the PGP mechanism.

Testing of the bio-control agent *Beauveria bassiana* to control greenhouse insect pests in aquaponics production system.

The project is run in collaboration with University of Alberta. Integration of fish into crop production system requires that conventional pest control tools have to be revised, as most of the widely used greenhouse pesticides will be toxic for fish. Pest control is one of the most challenging problems needing to be addressed in order to commercialize this new technology. This project is aiming to test the effectiveness of two *Beauveria bassiana* strains for selective control of common greenhouse pests and their toxicity for fish.

Litwinowich et al, 2004, reported that some of the isolated *Beauveria bassiana* strains from Alberta were more effective than commercially available *B. bassiana* (BotaniGard®, Mycotech Corp) for the control of western flower thrips (Litwinowich et al., 2004). Beauveria bassiana has also been shown to be a biocontrol agent against clover root weevil (*Sitona lepidus*) (Willoughby et al., 1998).

The aim of this study is to apply the isolated strain of *Beauveria bassiana* for control of greenhouse insects in aquaponics. The results of this study can also be applied in conventional hydroponic greenhouses.

Efficacy of precision placement carbon dioxide supplementation in greenhouse sweet pepper production

Most greenhouse vegetable growers in South Alberta use CO_2 burners to improve yields and size of fruits. Liquid CO_2 is considered as a safer source of carbon than CO_2 burners, which increase risk of crop damage by flue gases.

The objective of the project was to evaluate effect of liquid CO_2 by comparing production of sweet bell peppers in greenhouses with moderately low level of CO_2 and without liquid CO_2 supply using precision delivery system.

Five years of experiments with liquid CO_2 in greenhouses with commercial setup indicated high potential of the precision CO_2 delivery technology. However, the prohibitive cost of liquid carbon dioxide prevented growers in Alberta to switch from CO_2 burners to safer liquid CO_2. The results of these experiments indicated that lower level of CO_2 (400 ppm) allows to achieve higher yields in bell peppers, while decreasing consumption expensive commodity compared to recommended dosage 500 ppm 800 ppm.

Cultivation and assessment of rosemary as a greenhouse crop in Alberta

The project was conducted in collaboration with Special Crops Program, AAFRD.

Rosemary (*Rosmarinus officinalis* L.) is an evergreen woody aromatic herb

native of Mediterranean regions and is a very widespread shrub in Algeria, France, Italy, Portugal and Spain. Greenhouse culture of rosemary is important for production in South Alberta as this species does not survive in winter conditions in Alberta and the field season is short. Production of rosemary cuttings in greenhouse before transplanting seedlings to the field is therefore beneficial to produce maximum yield of rosemary as annual field crop. Greenhouse component is also important to maintain stock of mother plants for production of cuttings.

Rex was selected as a most promising line for further experiments. Six hundred cuttings were taken in the beginning of February, 2004 for experiments with nutritional factors and salinity stress. In the reported experiments there was no any significant effect of nitrogen observed either on yield or on TPA content observed. These results confirm the observations in field experiments at CDC South. The response of rosemary to nitrogen in the study is rather unusual and is probably related to relatively slow growth rate of this shrub. Therefore, the improvement of rosemary production has apparently genetic constraints rather than environmental limitations and should be based on selection of a fast growing variety producing highest yield of phenols. However, effect of balance of nitrogen with phosphorous and potassium cannot be ruled out and should be investigated in future studies for hydroponic rosemary production. Hydroponics technology proved to be a successful alternative to potted plants for greenhouse production of rosemary. Coconut coir was stable and provided good growing conditions for rosemary over one year period.

Subjecting hydroponically grown plants to moderate salinity (2000 ppm = 2 parts per thousand NaCl) during one week led to a 17.2% increase in total phenols. Total yield of phenols was significantly increased during short period of time with minimum investment. Further increase in salinity level did not result in the improvement of phenolic level. A positive effect of salinity treatment on quality of plant raw material was also observed in studies with glucoraphanin accumulation in plants of *Lepidium* (NIF project. Final report, AAFRD, 2004). These results suggest that application of moderate stress can be a valuable inexpensive tool to control quality of raw material for processing industry.

Chemical stress is inexpensive and effective method to stimulate some secondary metabolites including phenols in higher plants. A pioneering work in this area, which started in University of South Bohemia, proved technical feasibility of using chemical stress factors called elicitors in *in vivo*. In this trial the effect of two elicitors, A and B, was studied. The elicitors were applied in three concentrations. While there was a strong stimulating effect on phenols content observed when the plants were treated by Elicitor B, Elicitor A applied in increasing concentrations, inhibited phenols biosynthesis in rosemary. The level of phenols was increased for 16% when Elicitor B was applied in highest concentration. This study showed a good potential for methodology based chemical stress in order to increase compounds of interest for pharmaceutical industry. On the other hand, an individual study should be conducted to examine effect of specific elicitors in each case.

Evaluation of possibilities of producing high quality fibrous root of American ginseng (*Panax quinquefolius*) under Hydroponics and bioreactor conditions

This project is conducted in collaboration with Special Crops Program, AAFRD. The project started in the end of 2005. The system is an extension of recycling technology where nutrients are supplied through a solution to roots. This ensures

optimal supply of plant roots with oxygen and nutrients leading to fastest crop production rate. The technology is especially well suited for production of roots as the produced plant material is very clean and very easy to harvest.

Greenhouse production of *Ligusticum chuanxiona,* a novel medicinal herb in Canada

Ligusticum chuanxiong is a perennial flowering plant, which belongs to APIACEAE family. It is one of the most important medicinal materials in traditional Chinese medicines and it has been shown to treat headaches, chills, menstrual disorders, and many other diseases. It has potential for pharmaceutical industry in Alberta. The purpose of this study is to estimate biological productivity of the herb and a technical feasibility of greenhouse production of *Ligusticum chuanxiong* in Alberta. The objective of the project is to develop a technological protocol for a cost-effective production of *Ligusticum chuanxiong* in greenhouses. Five lines from China was successfully propagated and grown in growth chambers at CDCS in Brooks. The material was harvested and sent to Novokin, Edmonton, Alberta, for analysis.

Alberta Bioremediation Consortium was founded during the meeting on June 17, 2005, at Crop Diversification Centre South, Brooks, Alberta.

Initiatives

Alberta Bioremediation Consortium was founded during the meeting on June 17, 2005, at Crop Diversification Centre South, Brooks, Alberta. The purpose of the consortium was to initiate collaboration in phytoremediation area and to form an Alberta Bioremediation Consortium and to develop a sustainable solution for energy and oilfield reclamation industries to remediate contaminated soil.

Technology Transfer

The program leader N. Savidov, provided reports and technology transfer services to the industry, sharing crop production expertise regarding new crops and improved production techniques and technology.

The program leader also provided information to other department branches.

The greenhouse crops program also has a grower training program, which provides hands-on crop management and production training to individuals interested in becoming commercial growers. This program has produced growers who have gone on to become established owner/operators of successful commercial greenhouse businesses.

The program leader and personnel of the program gave presentations and participated in 12 workshops and conferences in 2005/2006. Trial results and articles are submitted regularly to *Greenhouse Business*, an Alberta Agriculture, Food and Rural Development newsletter for the greenhouse industry.

Nursery Crops Program

C.L. Murray, Program Leader
N. Seymour, Technologist

The nursery crops program has been focused on research into cultural management practices for commercial nursery production of both field and container-grown plants and the evaluation of new plant species and cultivars. Technology transfer activities included seminar presentations, magazine articles and research reports directed to growers and other members of the nursery-landscape trades industry as well as potential growers. A close association with Landscape Alberta Nursery Trades Association (LANTA) allowed for excellent communication with the commercial industry.

The program leader also provided information services to other AAFRD staff and to producer and commodity organizations. Details of research trials are presented in *Nursery Crops Program 2004*, CDCS Pamphlet 2005-8. In early 2006, the program leader undertook a new job assignment in Edmonton. The nursery crops program is being phased out.

Research Projects

Woody Plant Evaluation Trials

Regional woody plant test program

Standout selections were Cornus Alba 'Bailhalo' (Ivory Halo Dogwood) - an excellent hardy compact variegated dogwood: and Physocarpus opulifolius 'Diabolo' - a large upright ninebark with purple leaves and striking white flowers.

Since 1983, AAFRD staff, the LANTA Growers Group and Research Committees has cooperated to develop and maintain The Regional Woody Plant Test Program (RWPTP). New tree and shrub introductions, generally from North America, are evaluated for five years at six different sites representing different climatic regions in the province. Growth and landscape quality data are collected each year. Eleven new selections were planted at each site in the spring of 2005. The evaluation of seven new selections planted in 2000 was completed this year. Standout selections were *Cornus Alba* 'Bailhalo' (Ivory Halo Dogwood) - an excellent hardy compact variegated dogwood: and *Physocarpus opulifolius* 'Diabolo' - a large upright ninebark with purple leaves and striking white flowers.

For more information about the RWPTP see *Regional Woody Plant Test Project 2005, CDCS Pamphlet #2006-3* or on the internet at <http://www.agric.gov.ab.ca/crops/trees/rwptp/index.html>.

Prairie regional trials

The Prairie Regional Trials (PRT) were established in 1958 to evaluate the hardiness of woody plants on the Canadian Prairies and continue today in cooperation with AAFC - Morden in Manitoba. The plants in the PRT are evaluated for five years at seven prairie sites including CDCS. The growth and landscape quality data collected each year are sent to Morden where a report is

produced approximately every three years and is now available at the internet website <http://res2.agr.ca/winnipeg/prt59_58.html>.

Since 2002, there have been no additions to the trial. In 2000 there were six species and cultivars planted including *Acer sacharrinum* 'Skinner', *Aronia arbutifolia* O.P., *Juniperus x media* Pfitzeriana, *Salix pentandra* and numbered *Spiraea nipponica* and *Duetzia scabra plena*. The *Deutzia* did not survive the first growing season and the *Acer* had winter damage and poor branching habit. The remaining selections performed well and are recommended.

Alberta Perennial Garden Trial

In response to the huge growth in interest and sales of herbaceous perennials, the Calgary Zoo and Botanic Garden, LANTA Retail Operators Commodity Group and CDCS cooperated to develop the perennial demonstration and evaluation garden from 1999-2001at the Calgary Zoo in the Dorothy Harvie Gardens. A second phase of the trial began in the spring of 2002 with addition of demonstration gardens at the Olds College Botanical Gardens in Olds and at the Muttart Conservatory in Edmonton, Alberta. The project objectives are: 1) to evaluate new species and cultivars of perennials for hardiness and landscape quality under Alberta conditions; 2) to compile and publish the results for the public, retailers, growers and landscape professionals; 3) to increase the knowledge about new perennials.

This project was complete in the fall of 2004, a technical document *Alberta Perennial Trials 2002 –2004* has been published and is available from the LANTA Retail Operators Commodity Group. A public document was published in the spring of 2005 and is available at retail outlets.

A third phase began in the spring of 2005 where approximately 50 cultivars are added annually and evaluated over three growing seasons. This ongoing trial project will continue with industry support and sponsorship.

The evaluation of six systems of holding harvested trees during the shipping season

Caliper trees are harvested in a short period that begins with spring thaw and ends when the trees leaf out. There is a need for trees in the landscape industry from spring thaw to winter freeze up; thus, thousands of trees are held by growers across Alberta during the growing season.

Maintaining the quality of the trees during this period is important for trees to retain their value, continue to grow and transplant successfully. When trees are harvested, then balled and burlapped, as little as 5% of the root system is retained within the rootball. The remaining small root system must provide sufficient water and nutrients for the top to continue to grow and to grow replacement roots for those lost at harvest while the tree is being held before transplanting to its final location.

It is also important that the trees do not root out into the soil surrounding the rootball during this period. These newly developed roots are generally broken and destroyed by moving and shipping resulting in a second transplant shock for the tree.

Brandon Elm trees were harvested with a tree-spade, wrapped in burlap and placed in wire baskets and transported to CDC South, Brooks early June 2002. They were placed in a holding area in one of six systems; 1) placed back into

hole of the same size (control), 2) placed into hole of same size with dual layer plastic bag around rootball 3) placed back into hole with 1/3 of basket above ground 4) placed on surface of soil with dual layer plastic bag around rootball 5) placed on geotextile on soil surface and completely mulched with wood product 6) placed into hole of same size lined with geotextile. The trees were irrigated throughout the season.

Top-growth was measured in the fall of 2002. For half the trees in the fall of 2002 and the remaining in the spring of 2003, roots were harvested inside the original rootball as well as roots growing outside of the rootball into the surrounding soil or mulch. No differences in top growth or roots inside the rootball were found among treatments. The roots growing outside of the rootball were significantly greater for the mulched treatment (5) than the remaining treatments, followed by the 1/3 above ground treatment (3) and the control (1). Roots growing outside the rootball are likely to be damaged when the tree is moved to the landscape which may result in poor transplant success.

A final evaluation in the spring of 2005 showed that all the trees had excellent winter survival.

This trial was repeated in 2003 to measure the impact the holding system had on transplant success. Harvested Brandon Elms were placed in the holding area in identical treatments and the growth was measured on the trees. The trees were planted in the landscape in May 2004 by the City of Brooks and growth measurements and observations was be taken during the growing season of 2004.

For all the growth parameters Trt 2 where the trees were place in a dual layer plastic bag into the hole of the same size was consistently best and except for the top growth after transplanting, Trt. 5 has been least. However, trees in Trt. 5 produced the greatest weight of roots external to the rootball indicating these treatments likely expended more energy for root development than top growth.

A final evaluation in the spring of 2005 showed that all the trees had excellent winter survival except for one specimen from treatment 1 (control) with about 50% dieback. This single specimen likely suffered from environmental factors rather than treatment.

The impact of potassium on winter hardiness of six species of container grown shrubs

The objective of the project was to evaluate the impact that potassium (K) fertility may have on winter hardiness of container grown shrubs. Six species were potted into #2 pots in May 2004, and fertilized with three rates of K; low at 4g K/pot, medium at 6g K/pot and high at 8g K/pot. Nitrogen and phosphorous were applied at 6g/pot for all treatments and micronutrients at recommended rates. The species were: *Cornus alba* 'Bud's Yellow', *Philadelphus virginalis, Physocarpus opulifolius* 'Diabolo', *Potentilla fruticosa* 'Pink Whisper', *Rosa* 'Thérèse Bugnet', *Syringa meyeri.* These species were chosen based on growers experience of overwintering damage as container grown plants

In September 2004, growth index was measured and the pots were placed into three different overwintering treatments; 1) optimum - white plastic covered hoop house and plants covered with thermal blanket cover, 2) moderate - consolidate pots, surround with hay bales, 3) low - consolidate pots no other protection.

The temperatures in the pot were monitored through the winter 2004/05. In May 2005, dieback was pruned from the plants and the growth index were measured again. Top growth was harvested and dried. Dry Weight results showed that for

Cornus alba 'Bud's Yellow', *Syringa meyeri, Philadelphus virginalis,* and *Rosa* 'Thérèse Bugnet', treatments 1 and 2 were significantly better than 3. There were no differences in treatment for *Physocarpus opulifolius* 'Diabolo' and *Potentilla fruticosa* 'Pink Whisper'. Dry Weight results showed no significant differences in K fertility rates for *Cornus alba* 'Bud's Yellow', *Philadelphus virginalis,* and *Potentilla fruticosa* 'Pink Whisper'. For *Rosa* 'Thérèse Bugnet' and *Syringa meyeri* the best results at the low rate of K. *Physocarpus opulifolius* 'Diabolo' overwintered best at the high K rate.

The impact of zeolite as a soil amendment for three species of field grown nursery stock.

Zeolites are microporous crystalline solids with well-defined structures. Generally they contain silicon, aluminium and oxygen in their framework and cations, water and/or other molecules within their pores. Many occur naturally as minerals, and are extensively mined in many parts of the world. Others are synthetic, and are made commercially for specific uses, or produced by research scientists trying to understand more about their chemistry. Zeolites reduce nutrient loss due to leaching by increasing the retention of the nutrients and slowly releasing them as needed by plants. Experiments at AAFC - Summerland in 1995/1996 showed benefits of Zeolite for nursery crops.

A trial was conducted at CDCS in 2004 to measure the impact of Zeolite as a media component for the container grown shrub, *Potentilla fruticosa* 'Coronation Triumph'. There were no significant differences in growth over one growing season (Murray and Seymour, 2004). However, the benefit of zeolite may become significant over a period of two or three years when used as a soil amendment for field grown nursery stock.

In June 2005 *Fraxinus* x 'Northern Treasure' and *Malus* x 'Snowcap' whips and *Populus tremuloides* seedlings were planted with two rates of zeolite incorporated into the soil: 1) 900 g zeolite/plant 2) no zeolite, with nitrogen brought up to two levels: High – to 90 kg N/ha and Low 45 kg N/ha.

Caliper and growth index are measured each season and root growth will be measured at harvest after the second and third growing season.

Plant Collections

Plant collections have been developed and maintained at CDCS as a living reference collection for use by horticultural professionals and the general public. The **Golden Prairie Arboretum** was established in 1981 at CDCS. The collection now contains 312 species of 68 genera for a total of 531 deciduous trees and shrubs. These plants represent most of the deciduous woody plant species that can be grown on the prairies. A complete listing of the collection is available in *Golden Prairie Arboretum, ASCHRC Pamphlet 93-1.* The **Forever Green Pinetum** collection of coniferous trees and shrubs at CDCS was established in 1986. At present it contains 26 species of nine genera for a total of 120 trees and shrubs. A complete listing of the collection is available in *Forever Green Pinetum, ASCHRC Pamphlet 93-12.* The **Rose Garden** contains 241 specimens, many of which are unique to the CDCS collection. Many early Canadian rose cultivars and notable crosses of Canadian rose breeders, Skinner, Bugnet and Wallace are maintained in the collection. The Communities in Bloom Committee in Brooks have carried out maintenance for the past two years of the rose garden on a volunteer basis under the direction of the Nursery Crops Technologist. Routine maintenance was carried out in the other areas.

Technology Transfer

Technology transfer to the growers has been accomplished through work with the LANTA Growers Group, Western Nursery Growers Group, and by the production and distribution of the Nursery Crops Trial Report and other published material, updating a website database and the presentation of seminars including research update at the Alberta Horticultural Congress.

Plant Pathology Program

R.J. Howard, Program Leader
S.L.I. Lisowski, Technologist,
M.W. Harding, Research Associate,
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S.A. Pugh

The plant pathology program conducts applied research on economically important diseases of horticultural, special and forage crops. These studies involve field, laboratory, growth chamber, controlled environment storage and greenhouse experiments, as well as disease surveys. Although most of the program's activities are carried out in southern Alberta, a few trials and surveys are also conducted in central and northern Alberta. Projects are supported by funding from external sources such as the Agriculture Funding Consortium, commodity organizations, grower associations, and seed, pesticide and equipment companies. Program staff collaborate with colleagues at CDC South and other research institutions, as well as with various industry partners, in carrying out research, disease survey and technology transfer activities. Some of the program's key external cooperators in 2005 were:

Greenhouse Crops – M. Mohyuddin, AAFRD, Edmonton; P. Bains, Agri-Research Ltd., Edmonton; P. Kharbanda and J. Yang, ARC, Vegreville

Potatoes – P. Bains, Agri-Research Ltd., Edmonton; P. McAllister, AAFRD, Edmonton; A. Parra, PGA, Taber; K. Basu, BioVision Seed Labs, Edmonton; L. Kawchuk, AAFC, Lethbridge; J. Thomson, Univ. Sask., Saskatoon, SK

Pulse Crops – K.F. Chang and H.U. Ahmed, AAFRD, Lacombe; S.F. Hwang, ARC, Vegreville; L. Andersen and J. Rex, Agricore United, Bow Island and Taber

Vegetable Crops – S. Strelkov, Univ. Alberta, Edmonton, J. DeMulder, AAFRD, Edmonton; R. Spencer, AAFRD, Stettler.

Diseases of Greenhouse Crops

Improved management of root and stem rot diseases in greenhouse cucumber

An electrochemically activated (ECA) water machine provided by ECA Solutions Canada Ltd., Abbotsford, BC, was installed in a CDCS greenhouse in 2004. This machine generates disinfectant ions, mainly free chlorine, from a potassium chloride brine solution that passes through its electrodes. The disinfectant solution can be added to the nutrient feed in order to disinfest the solution and to prevent root infections from pathogens such as *Pythium* and *Fusarium*. This trial commenced in September and continued until the end of November, but a few problems occurred with the nutrient delivery system in the greenhouse and it was decided to repeat the trial. Two additional trials with the ECA machine were completed in August and December, 2005. In both cases, a cucumber crop was planted with half of the house on sawdust and half on cocopeat bags. The summer trial had four treatments, including *Pythium*-inoculated/non-inoculated and chlorinated/non-chlorinated nutrient solutions, which were evaluated for their effects on plant health and yield. The results were inconclusive for this trial and very few plants died, even after inoculation with *Pythium* and no addition of ECA. It is hoped that this trial can be repeated in 2006, as there were few apparent differences between all treatments and it was suspected that the ECA was not reaching the plants with the nutrient feed. In a fall trial, *Fusarium*, rather than *Pythium* was added to the nutrient solution, and the chlorination procedure to the nutrient tanks was optimized after trouble-shooting by Program staff. Data analysis is pending, but the results looked promising with very little disease and no plant death noted in the plants, which receive ECA nutrient solution.

Efficacy of Chemprocide disinfectant against botrytis stem canker of greenhouse tomato

Gray mold, caused by the fungus, *Botrytis cinerea*, is a widespread and serious disease of greenhouse tomatoes. The petioles, leaves, stem and fruit can be attacked and destroyed by this pathogen. Botrytis stem rot is a very prevalent symptom, which manifests as large lesions, which can girdle the stem, causing wilting and plant death. As there are no disease-resistant tomato varieties currently available, growers traditionally attempt to control this disease by using cultural practices and fungicides. Chemprocide™ (Pace Chemicals) is currently registered as a greenhouse disinfectant and has broad-spectrum antimicrobial properties. However, the label has not been expanded to include direct applications to tomato plants for disease prevention and control. This project, which commenced in July 2005 in a CDCS greenhouse, was conducted to determine if this product is effective non-phytotoxic when directly sprayed on tomato plants to prevent and/or control botrytis stem rot. The tomato plants were grown on coconut fibre substrate bags in four replications with ten treatments, including the registered fungicide Rovral. As this trial is still in progress, no results are available yet.

Efficacy of electrochemically activated (ECA) water against *Pythium aphanidermatum*

Electrolyzed water is made by electrolysis of dilute salt solutions. The resulting electrolytes are known to have biocidal properties due to high oxidative-reductive potentials. These oxidizing ions and radicals may be useful for

disinfection of greenhouse surfaces and systems because they can be generated *de novo* on-site. Electrolyzed water was evaluated for its effectiveness at eradicating the filamentous oomycete *P. aphanidermatum*, a root pathogen of numerous greenhouse crops. The fungus was grown planktonically in liquid media or as mycelial films on carrier surfaces and challenged with electrolyzed water at various concentrations and successive exposure times. The results verified that electrolyzed water was fungicidal and that contact times required to kill *P. aphanidermatum* were inversely related to concentration.

The effects of the ECA solution were fungicidal at higher concentrations; however, the treatments with ½ X dose were not fungicidal as viable colony forming units were observed for planktonics even after 24 hr exposures.

Efficacy of electrochemically activated (ECA) water against *Fusarium oxysporum*

Electrolyzed water was tested against *F. oxysporum*, another serious greenhouse pathogen, in a manner similar to *Pythium aphanidermatum* (see above). Fungal suspensions or impregnated carriers were exposed to one of two ECA concentrations successive contact times and then plated on agar plates to determine survival. There was a general reduction in the survival of *F. oxysporum* as ECA treatment exposure times increased, and contact times greater than 2 hr were sufficient to eradicate both planktonic and biofilm forms of the fungus. The effects of the ECA solution were fungicidal at higher concentrations; however, the treatments with ½ X dose were not fungicidal as viable colony forming units were observed for planktonics even after 24 hr exposures. The results showed that eradication of *F. oxysporum* growing in liquid or on solid surfaces required a more concentrated dose and longer contact time than *P. aphanidermatum*.

Evaluation of commercial and experimental disinfectants for efficacy against selected bacterial, fungal and viral pathogens of greenhouse vegetable crops

Nine commercial and experimental disinfectants were tested for efficacy against seven pathogens of greenhouse vegetables. Fungal, bacterial and viral pathogens were challenged with disinfectants in isolated cultures and subsequently sampled for survival. Additionally, the microorganisms were used to artificially infest small coupons made from various greenhouse surface materials such as copper, aluminum, steel, stainless steel, galvanized tin, polyethylene, polycarbonate, polyvinylchloride, glass, wood, rubber, and concrete. The infested surface coupons were then treated with disinfectants and sampled to test for microbial survival. This two-pronged approach allowed for rigorous testing of active ingredient vs. microbial pathogen, as well as test for efficacy in an environment that paralleled actual greenhouse conditions.

Results of *in vitro* trials showed that all disinfectants caused inhibition of microbial growth; however, some compounds caused a stasis, rather than mortality. Disinfestation of surfaces revealed that surface characteristics, including porosity and hydrophobicity, could negatively impact the activity of chemical disinfectants. Additionally, rapid drying and increased organic load could reduce disinfectant efficacy. The data showed that disinfectants did not perform equally against all pathogen types, e.g. some were effective fungicides, but were not virucidal.

The nine disinfectants were also rated for potential corrosive or damaging effects on greenhouse surfaces, and for human and environmental health and safety hazards. Corrosion analyses showed that the quaternary ammonium disinfectants were the least corrosive, followed by other non-oxidizing formulations,

while oxidizers were the significantly corrosive to metals. Information on environmental toxicity and personal health and safety hazards available from labels and MSDSs indicated that electrolysed water and benzoic acid were the least harmful active ingredients.

Diseases of Potatoes

Screening advanced potato-breeding lines for foliar resistance to brown spot and early blight

Sixteen advanced breeding lines and two standard cultivars from the Western Canadian Potato Breeding Program based at AAFC, Lethbridge were screened for resistance to early blight (*Alternaria solani*) in a naturally infected field plot at CDCS. Three visual estimates of disease incidence and severity for both the field canopy and compound leaf samples were taken, starting with two assessments starting in mid-August and a final one during the first week in September, when blight levels were extremely high. Disease pressure was on the increase, even by the first evaluation date, and by the final date, the crop was nearly destroyed by early blight. By the end of the experiment, only two breeding lines, FV12246-6 and FV12486-2, demonstrated as much resistance to blight infection as the resistant standard, Russet Burbank.

Diseases of Pulse Crops

A field evaluation of three registered fungicides for controlling white mold in dry beans

Three fungicides registered for use on dry beans in Canada, i.e. Lance, Rovral and Senator, were compared for their ability to control white mold in two commercial bean fields in southern Alberta. These fields were naturally infested with the white mold pathogen, *Sclerotinia sclerotiorum*. The plot design was a randomized complete block with four replications. The fungicides were applied either once at the full label rate, twice at a reduced ("split") rate or alternated with each other. Trials were conducted and Van der Hoek Farms, Vauxhall, AB and at Bennen Farms, Vauxhall, AB. Disease incidence, disease severity and yield data were taken. No single treatment stood out as being the most effective on both farms and there was no clear advantage of full rate over split rate applications or vice versa. The untreated checks at both sites generally had the most disease and the lowest or next to lowest yields, suggesting that the fungicides were affording measurable protection against infection. Statistically significant difference between treatments were observed only at Van der Hoek Farms, where most of the fungicide treatments has significantly less disease and higher yields that the check.

A field evaluation of four registered and two unregistered fungicides for controlling white mold in dry beans

Two commercial dry bean fields in southern Alberta were selected for replicated trials to compare the efficacy of four registered (Botran, Lance, Rovral and Senator) and two unregistered (Ronilan and Calmax Extra) fungicides on white mold. These fields were naturally infested with the white mold pathogen, *Sclerotinia sclerotiorum*. The plot design was a randomized complete block with four replications. The fungicides were applied two or three times at a reduced ("split") rate, or alternated with each other. Trials were conducted at Koomen

Farms, Taber, AB and at Burbridge Farms, Burdett, AB. Disease incidence, disease severity and yield data were taken. The Lance + Calmax Extra + Lance treatment stood out as being the most effective application regime on both farms in terms of reducing disease and/or improving yield. In contrast, Calmax Extra alone performed relatively poorly compared to the other fungicides under test. The untreated checks at both sites generally had the most disease and the lowest or next to lowest yields, suggesting that the fungicides were affording some degree of protection against infection. Statistically significant differences between treatments were observed only at Koomen Farms, where most of the fungicide treatments has significantly less disease and higher yields that the check.

An on-farm trial to assess aerial and broadcast methods of fungicide application for controlling white mold on dry beans conducted at Bennen Farms, Vauxhall, AB

Lance WDG fungicide was applied twice to a dry bean field consisting of two cultivars using three application methods. These included an aerial application, a broadcast application with a water volume of 170 L/ha (single nozzle @ 15 gal/ac) and a broadcast application with a water volume of 340 L/ha (dual nozzle @ 30 gal/ac). Each treatment was applied to both cultivars. The aerial application outperformed the broadcast applications for AC Polaris for both disease control and yield, but not for US1140. The 350L/ha application rate performed better than 170L/ha for the two broadcast application regimes.

An on-farm trial to assess band and broadcast methods of fungicide application for controlling white mold on dry beans at Burbridge Farms, Burdett, AB

Lance™ WDG fungicide was applied twice to a dry bean field using three application methods. These included one application with a band sprayer, two applications with a band sprayer, one application with a broadcast sprayer, and two applications with a broadcast sprayer. There was also an untreated check that received no fungicide sprays. Lance proved to be highly effective in controlling white mold compared to the untreated check. All three of the fungicide application methods resulted in significantly lower levels of disease and much higher yields that the unsprayed control. Although there were minor differences in white mold disease incidence and yield between the three application methods, none was significantly better than the other under the conditions of this trial. This trial clearly demonstrated the benefits of properly timed and applied fungicide sprays for controlling white mold.

An on-farm trial to assess two fungicides and three cultivars for controlling white mold on dry beans conducted at Klempnauer Seeds Limited, Grassy Lake, AB

Lance™ WDG was applied twice to a field comprised of three dry bean cultivars (Othello, CDC Pinnacle and CDC Polar Bear) destined for pedigreed seed production. Lance™ WDG and Ronilan® EG were applied twice to separate strips in another field of CDC Pinnacle seed beans. Lance appeared to be more effective than Ronilan under the conditions of this trial. CDC Pinnacle and CDC Polar Bear were less susceptible to white mold than Othello.

An on-farm trial to assess aerial and broadcast methods of fungicide application for controlling white mold on dry beans at Koomen Farms, Taber, AB

Lance™ WDG was applied once to a field of AC Redbond dry beans by air just after irrigation and ground application methods 24 hrs prior to irrigation. There was also an untreated check strip that was not sprayed. Lance substantially reduced the levels of white mold in both the aerial and ground-sprayed strips relative to the control. Although aerial application reduced the disease by about 5% more than the ground sprayer, the latter method improved the yield by about 9% over the aerial treatment based on the hand-harvested samples.

An on-farm trial to assess band and broadcast methods of fungicide application for controlling white mold on dry beans at Pepneck Farms, Vauxhall, AB

Lance™ WDG was applied to a dry bean field with three application methods. These included a broadcast application, a band application with a two-nozzle system and a band application with a three-nozzle system. Each spray treatment was applied twice and the three application methods were tested on both the east and west halves of the field. Although the band-sprayed strips generally had less disease than the broadcast-sprayed strips, the yields in the broadcast strips were higher.

An on-farm trial to assess two fungicides for controlling white mold on dry beans conducted at Pooleside Farms Limited, Burdett, AB

Four different combinations of two fungicides were tested in two fields of AC Polaris dry beans. These combinations included: Benlate® 50WP/Benlate® 50WP compared to Benlate® 50WP/Lance™ WDG, and Lance™ WDG/Lance™ WDG compared to Benlate® 50WP/Lance™ WDG. All products were applied with a broadcast sprayer. All of the products under test kept the white mold levels low. In general, the treatments that included Lance appeared to perform better the one where Benlate was used alone.

An on-farm trial to assess aerial and broadcast methods of fungicide application for controlling white mold on dry beans at Van der Hoek Farms, Vauxhall, AB

Lance™ WDG was applied once or twice to a field of AC Redbond dry beans using three application methods. These included an aerial application and one or two broadcast applications. Although disease levels were somewhat lower in the part of the field sprayed by air, yield was slightly higher in the double broadcast-sprayed strip.

Effect of irrigation management practices on yield and disease occurrence in dry beans

A field trial was established at the Crop Diversification Centre South's Bow Island Substation by Irrigation Branch staff to assess the efficacy of irrigation management practices on production, soil fertility and conservation, and pest management. Six irrigation treatments with four replications were arranged in a randomized complete block design. Disease incidence and disease severity data were taken. On July 26, no bacterial blight or white mold was observed, while

on August 25 both of these diseases were seen in some subplots, but there were no statistically ($P \leq 0.05$) significant differences between treatments. All subplots had a high incidence of root rot which was greater than 50% in most cases; however, there were no statistically ($P \leq 0.05$) significant differences between treatments.

Alternative seed treatments for controlling bacterial blight diseases of dry beans

For over a decade, growers in Alberta have relied upon streptomycin sulphate to help control bacterial pathogens on dry bean seed. The main organisms being targeted are brown spot (*Pseudomonas syringae* pv. *syringae*), common blight (*Xanthomonas axonopodis* pv. *phaseoli*), and halo blight (*Pseudomonas syringae* pv. *phaseolicola*). In 2002, the PMRA approved a minor use registration of cupric sulphate pentahydrate and Vitaflo 280 for controlling seed-borne bacterial blights. This mixture has been used primarily to treat domestically produced bean seed destined for planting in Canada because U.S. seed distributors are not set up to apply cupric sulphate in their seed treating plants, and, furthermore, this product is not registered in the U.S. for this particular use. Some Canadian seed treatment plants have encountered difficulty in getting cupric sulphate to dissolve in water prior to mixing it with Vitaflo 280 and would prefer a more water-soluble product. They have requested a re-evaluation of fixed copper products. As a result, initial screenings of six copper fungicides in the laboratory and greenhouse were started in 2005 and will be completed in 2006.

Studies on the management of ascochyta blight of chickpea

A second year of trials was conducted at CDCS in 2005 in order to develop a program for the sustainable management of the ascochyta blight, a devastating disease of chickpea. Experiments were conducted at two sites, the Lendrum and McLeod farms. Due to heavy rainfall and root rot, most of the plants were damaged at Lendrum farm and hence the trials were abandoned, except for a seed treatment trial. We are presenting the data mostly obtained from the experiments conducted at the McLeod farm in 2005.

Screening for resistance to ascochyta blight of chickpea

Twenty-two chickpea cultivars and lines were evaluated in a replicated trial against ascochyta blight following artificial inoculation by spreading wheat grain inoculum and diseased debris in the plots. There were wide ranges of disease severity (DS = 2.5 - 8.7), based on a 1-9 scale, among the test entries. Based on the reactions 13 chickpea entries were resistant (scale 2 - 3), 4 moderately resistant (4-5), and 5 susceptible (6-9). Orthogonal contrasts between the unifoliate type of chickpea and compound-leaved type indicated that unifoliate chickpeas were more susceptible, which was consistent with other studies at the same location and reporting year. However, this trial was conducted once only and needs to be repeated.

Effect of plant spacing and seeding rate on ascochyta blight and yield of chickpea

An experiment consisting of two chickpea cultivars CDC Xena (kabuli; unifoliate) and CDC Anna (compound-leaved; desi), three row spacings (20, 30 and 40cm) and three seeding rates (20, 40, 60 seeds in a 3 m row) were planted at CDCS and monitored for disease incidence and severity of infection by *A.*

rabiei. Results indicated that significant differences in disease levels existed between cultivars and among row spacing and seeding rate treatments. The largest amount of variation was explained by cultivar, followed by seeding rate and row spacing. Disease severity was higher on unifoliate kabuli compared to compound-leaved desi, closer row spacing and higher seeding rate. In 2005, the disease incidence reached 100% irrespective of the cultivar, row spacing and seeding rate well before the final disease scoring. However, the overall disease severity was less compared to 2004. As in previous years, regression analysis revealed highly significant ($P<0.001$) and linear positive relationship (R^2 = 87) with plant density and ascochyta blight disease severity. Linear negative relationships were observed between plant density and yield (g)/plant (R^2 = 67). A similar linear negative relationship (R^2 = 54) was also found between disease severity and yield (g)/plant, although, in these cases, the relationships were not that strong, but the regression was statistically significant at P <0.01 - <0.05.

Efficacy of fungicide as seed treatment to control ascochyta blight of chickpea

To determine the effect of seed treatment with fungicides on the emergence of seedlings as affected by *Ascochyta rabiei* experiments were conducted under field conditions at Lendrum and McLeod farms. Six fungicides, Apron FL, Apron Maxx, Crown, Dividend XL RTA, Maxim PSP, and Vitaflo 280, were tested in both the trials. An untreated control was also included in the trials. Seed treatments included Apron FL, Apron Maxx, Crown, Dividend XL RTA, Maxim PSP and Vitaflo 280. The Kabuli chickpea CDC Xena was used as test cultivars. Seed treatment with Vitaflo 280, Apron Maxx, Apron FL or Crown significantly increased seedling emergence over the untreated control confirming the last year findings. The effect of Maxim PSP was inconsistent, and Dividend XL RTA reduced seedling emergence compared to the control, indicating phytotoxicity.

Efficacy of foliar fungicides for the control of ascochyta blight of chickpea

An experiment was conducted to determine the effect of the foliar fungicide Headline 250 EC in a replicated trial under natural infection condition. The test cultivar was CDC Xena. The fungicides were applied 1-7 times at one-week intervals starting when the disease was first observed. Unsprayed plots were served as control treatments. Data on disease severity was recorded at 41, 83 and 124 days after seeding, and areas under disease progress curves (AUDPC) were calculated. Percent control efficacy (%CE) calculated as %CE = 100 – Dt/Du x 100 where Dt = disease in treated plot and Du = disease in untreated plot using both disease severity and area under disease progress curves. Result indicated that foliar application of Headline alone significantly reduced disease severity by 13.6 - 78.1 % and the area under the disease progress curve 16.9-91.3, confirming the last years finding where Headline and Quadris were used alternately. Two years of data indicated that at least four foliar applications are required to achieve 50% control efficacy. However, the higher control efficacy was obtained when disease pressure was relatively low (2005) and with a higher number of spray applications.

General Conclusions

Fungicide seed treatment effectively increased stand establishment, and a post-emergence foliar spray reduced ascochyta blight of chickpea. Plant population density increased disease severity and on the other hand reduced yield of

chickpea. The results suggest that reduced plant density by widening row spacings and reducing seeding rates, in conjunction with the use of resistant cultivars and fungicides may be a useful option to control ascochyta blight of chickpea.

Development of pesticides and disinfectants for prevention and control of microbial biofilms associated with plant diseases and seed pathology

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Microbes are routinely studied as free-floating or free-living cells. However, in most cases, this morphology does not parallel the complex organizations and arrangements that exist in natural or agricultural settings. For example, biofilms are compact, highly aggregated groups of cells that produce extracellular matrices allowing adhesion and protection from external forces or challenges. Biofilms on surfaces (often referred to as "slime") frequently exhibit resistance to removal and disinfection. As a result, past and current experimental results often overestimate the efficacy of chemicals used as antimicrobial cleaners, pesticides or disinfectants. This project, which is funded by the Alberta Agriculture Funding Consortium and Alberta Ingenuity Fund (Dr. Marques, Industrial Associate), involves the assessment of the role of biofilms in plant diseases, and to pinpoint effective materials (or combinations of materials) and strategies that may be used in management of disease-associated biofilms. The project has five main objectives: 1) Characterize plant pathogenic biofilms formed by fungi and bacteria on plant surfaces, including seeds and vascular tissues; 2) Evaluate the efficacy of currently used pesticides against plant pathogenic biofilms, in agricultural settings such as greenhouses and storage facilities, identifying possible ways to enhance their efficacy and disease prevention; 3) Identify novel products and/or combinations to eliminate plant pathogenic biofilms *in planta* and production/storage surfaces; 4) Develop new cost-effective seed treatment products; and 5) Educate the agricultural sector regarding the role of biofilms in plant disease.

Microscopic evaluations have demonstrated that plant pathogenic microbes grow on and in plants as biofilms. Using patented MBEC technology, we can analyze the *in vitro* growth and responses of microbial biofilms to various stresses. This information and technology can help elucidate the role of biofilms in disease cycles, and will be used for rapid screening of compounds with increased efficacy against biofilms to enhance disease management capabilities.

Determining the cause of early yellowing syndrome on dry beans in Alberta

Six bean fields in the Taber area with EYS symptoms were visited in August and soil and tissue samples were taken for analysis. A preliminary review of the data showed that soil salinity was associated with areas of severe symptom development in four fields and with root rot in one field. No marked nutrient deficiencies or excesses were associated with symptomatic plants in any of the fields where samples were obtained and tested. A review of EYS outbreaks from previous years and literature reviews are continuing.

Diseases of Vegetable Crops

Survey for clubroot disease in cruciferous vegetables

Clubroot is a root disease caused by the parasitic slime mold *Plasmodiophora brassicae* Woronin. In past years, this disease has been reported sporadically in isolated fields. For example, one field near Leduc reported clubroot in 2001, the first reported occurrence in many years. However, in the past two years, clubroot has been confirmed in canola fields in Alberta for the first time. For this reason, a provincial survey for clubroot was initiated in canola and cruciferous vegetables to establish the incidence, distribution and damage associated with this disease. In 2004, no clubroot was reported in vegetables across Alberta. In 2005, the vegetable survey was restricted to the greater Edmonton area, which is the location of clubroot infestations in canola fields. Nine commercial vegetable farms and gardens were surveyed for clubroot symptoms. Within these locations, 84 vegetable plots from 16 different fields were sampled between August 29 and September 2, 2005. In total, twelve different types of cruciferous vegetables were examined as they occurred at each of the 84 plots. Clubroot was found on two farms: 1) a single root gall was observed on one of 125 roots of the cabbage cv. Brutus sampled at a location in Edmonton, and 2) an estimated 50% yield loss in a field of cauliflower near Wetaskiwin. These plants exhibited stunting, wilting and root rot, and many of the heads were small and unmarketable. Clubroot disease surveys in 2004 and 2005 indicated a rise in the incidence and severity of clubroot in vegetables in central Alberta. However, environmental conditions play a major role in clubroot disease outbreaks; therefore, the increased incidence in 2005 may have been an isolated and infrequent occurrence similar to 2001. Continued surveys will be necessary to determine whether clubroot is increasing in frequency and distribution.

An evaluation of fungicides for the control of clubroot disease on cruciferous vegetables

A project was initiated in 2005 to screen five fungicides (Allegro 500F, Bli-Nix, Ferti-Cal 12.25 Ca, Quintozene 75WP and Ranman 400SC) for efficacy against soil-borne clubroot under field conditions at the Crop Diversification Centre North, Edmonton. The trial was direct seeded on June 30 and a small quantity of clubroot spores was applied with the seed to supplement naturally occurring levels of the pathogen. Each fungicide was mixed in water and applied at the rate of 5L of solution per 5m of row of cv. Granaat Chinese cabbage immediately after seeding. The crop was grown through to maturity at which time all of the plants in each row were dug and rated for disease incidence and severity. Yields of marketable heads were also taken. Disease levels in this trial were relatively low and there was an inoculum gradient across the replicates, which resulted in a high coefficient of variation. No significant differences in clubroot incidence, severity or yield were seen between the various treatments.

An evaluation of resistance to clubroot in cultivars of cruciferous vegetables

Forty-seven cultivars of cruciferous vegetable crops, consisting of broccoli (11 cvs.), brussels sprouts (3), cabbage (6), cauliflower (3), Chinese cabbage (7), kohlrabi (3), radish (9), rutabaga (2), and turnip (3), were screened for resistance to clubroot in a naturally infested field a CDC North, Edmonton. The trials were direct seeded on June 30. The crops were grown through to near maturity, and all of the plants in each row were dug and rated for disease incidence

(DI) and severity (DS); no yield data were taken. Disease levels in this trial ranged from low to high because there was a strong inoculum gradient across the replicates. This resulted in a high coefficient of variation. No significant differences in DI or DS were seen between the various cultivars of broccoli, brussels sprouts, cauliflower, kohlrabi, radish, rutabaga and turnip under test. In Chinese cabbage, cv. Bilko has a significantly lower DI than cvs. Blues, Mirako, Nikki and Joi Choi; however, it was not significantly different from cvs. Kasumi and Pak Choi FQC. In white cabbage, cvs. Blue Thunder and Lennox had significantly lower DI and DS values than cvs. Manoko and Optiko, but were not significantly different from cvs. Headstart and Cortes.

Potato Agronomy Research Program

M. Konschuh, Program Leader
S. Dalpé, Technologist

Alberta's Potato Industry

In 2005, more than 51,000 acres of potatoes were grown here; 38,000 acres for processing, much of it contracted production; approximately 10,500 acres for seed potatoes and 2,500 acres for tablestock.

After the rapid expansion of the potato industry from 1998 to 2003, potato acreage has levelled out in Alberta. While other potato growing areas in Canada and the U.S. are cutting back acreage in response to decreased consumption and export of potatoes, Alberta planted similar acreage in 2005 as in 2004. In 2005, more than 51,000 acres of potatoes were grown here; 38,000 acres for processing, much of it contracted production; approximately 10,500 acres for seed potatoes and 2,500 acres for tablestock. There are three major fry processing plants in southern Alberta, two potato chip plants, a dehydration facility and a number of packers. The overall value of the industry in Alberta has been estimated at over $300 million dollars.

As of 2005, Alberta is the second largest producer of potatoes in Canada, second only to Prince Edward Island. Although Prince Edward Island, New Brunswick and Manitoba plant more acres of potatoes, Alberta has enjoyed the highest average yields in Canada for several years.

Potato Agronomy Research Program

The objectives of the Potato Agronomy Research program are to foster increased production efficiency and competitiveness of the potato industry in Alberta. Issues affecting irrigated potato production for processing and tablestock (seed potato issues are addressed by Tricia McAllister at CDCN) are the program's main focus. The majority of the research trials are sponsored by industry or industry organizations. In 2005, approximately 50% of the trials were conducted in small plots at CDCS, while the other 50% were conducted in co-operator fields near Scandia, Vauxhall, South Hays, Purple Springs, Taber, and Grassy Lake. It is generally easier to control experimental parameters in small plot trials, but yield estimates and crop quality are often more realistic in grower controlled settings.

Research Projects

Timing of power hilling for Russet Burbank in southern Alberta

The purpose of this 3-year project was to compare not hilling with conventional and power hilling at regular intervals after planting to determine how much damage and yield loss is sustained as a result of late hilling operations. Potatoes were graded for total yield, marketable yield, deformities, greening and internal defects. In 2003, all hilled treatments resulted in greater total yield than the control (not hilled). In 2004 and 2005, however, the control (not hilled) treatment resulted in yields not significantly different from the best-hilled treatments. The greatest total and marketable yields were observed when potatoes were power hilled at ground crack in 2003 and 2005, and at emergence in 2004. Soil temperature was monitored in hills from each treatment in 2004 and 2005. Power hilled treatments provided greater insulation against environmental temperature fluctuations than disc hilling. If power hilling has not been completed by the time tuber initiation begins, disc hilling may result in a better combination of marketable yield and good fry colour than power hilling late. Poor timing of hilling and not hilling decreased the uniformity of tuber size.

Poor timing of hilling and not hilling decreased the uniformity of tuber size.

This trial was done at CDCS.

Lutein content of yellow-fleshed potatoes grown in Alberta (sponsored by Ag & Food Council, PGA, Lamb-Weston, Edmonton Potato Growers, Little Potato Company, Parkland Seed Potatoes, HZPC Seed Potatoes and Solanum International)

This project is a follow-up to a preliminary lutein screening project funded in 2004. Lutein is a carotenoid compound associated with reduced incidence of age-related macular degeneration and cataract formation. The current 2-year project involves growing ten of the cultivars of yellow-fleshed potatoes screened in 2004 at Brooks, Edmonton and Lacombe Alberta. Composite samples from each location will be used for analyses of flesh color intensity, total carotenoid content and lutein concentration. Analyses have not yet been completed for 2005. Potato cultivars with significant concentrations of lutein may be marketed in the future as functional foods.

This trial was done at CDCS.

Effect of Royal MH60 SG for size control of Russet Burbank potatoes (sponsored by Crompton)

Royal MH60 has been marketed as a growth regulator applied in-season to potatoes to confer sprout inhibition in storage. Recently, claims that MH60 can improve grade and quality of potatoes increased interest in the product. Royal MH60SG (maleic hydrazide) was applied to one half circle (approximately 65 acres) of a commercial field of Russet Burbank (processing) potatoes when tubers were at least 2 inches in diameter. Application of MH60 at the correct stage of development resulted in greater total yield and greater yield of desirable size categories (6 to 10 oz. and > 10 oz.) compared to the check, although there was a high degree of variability throughout the field. The yield increases observed were sufficient to justify the expense of an MH60 application. The quality of the tubers remained unaffected at harvest. Sprout control and storage

quality were not assessed as part of this study as these effects of MH60 are quite well documented.

Effect of MH60 for size control in chipping potatoes (sponsored by Crompton)

Royal MH60 has been marketed as a growth regulator applied in-season to potatoes to confer sprout inhibition in storage. Claims that MH60 can improve grade and quality of chipping potatoes from storage increased local interest in the product. MH60 (maleic hydrazide) was applied to one half circle (approximately 65 acres) of a commercially grown field of chipping potatoes (AC Glacier Chip) when tubers reached 2" in diameter. There was a trend toward greater total and marketable yield and good quality tubers from the MH60 treated portion of the commercial chipping potato field compared to the check in this study. Anecdotal observations from the grower confirm sufficient yield increases of marketable potatoes to justify the expense of an MH60 application. There was a high degree of variability throughout the field, however, and the differences observed were not statistically significant. Sprout control and storage quality were not assessed as part of this study as these effects of MH60 are quite well documented.

Western Canadian Potato Breeding Program Regional Trials – Early, Maincrop and North Central Trials (in cooperation with Agriculture and Agri-Food Canada)

As part of AAFRD's ongoing support of the Western Canadian Potato Breeding Program and the role it plays in the competitiveness of the potato industry, early crop (80 and 95 day harvests) and maincrop regional trials and a North Central Trial on behalf of the Western Canadian Potato Breeding Program were conducted at Brooks. Twelve cultivars were evaluated against check cultivars (Atlantic, Norland, Russet Norkotah, AC Ptarmigan and Norvalley) approximately 80 days after planting and again approximately 95 days after planting in the early crop trial. Twenty-two cultivars were evaluated against check cultivars (Atlantic, Norland, Russet Norkotah, Ranger Russet, Russet Burbank, Sangre, Shepody and Snowden) in the maincrop trial. Data were collected on 30 to 40 agronomic and quality factors including yield, maturity, specific gravity, and culinary and processing quality. Another eleven lines were compared to seven check cultivars (Atlantic, Norland, Norvalley, Red Pontiac, Russet Burbank, Russet Norkotah and Snowden) as part of a North Central trial comparing breeding material from Alberta with that of programs located in the north central U.S.A. Four of the cultivars evaluated came out of the Western Canadian Potato Breeding Program. (FV12246-6, FV12486-2, V0319-1 and V1102-1). Data for these trials are provided to the Potato Breeder with Agriculture and Agri-Food Canada - Lethbridge.

This trial was done at CDCS.

Field-scale Quadris in-furrow at planting – southern Alberta (sponsored by Growers Supply Ltd.)

Quadris (azoxystrobin, Syngenta) has been registered for several years as a foliar fungicide providing good in-season control of early blight on potatoes. Recently, the label was expanded to include an in-furrow at planting (IFAP) application for protection against *Rhizoctonia solani*. Under contract, program staff sampled for *Rhizoctonia* (stem and stolon canker and black scurf) from a Quadris IFAP

treated and a check portion of a commercial field of Russet Burbank potatoes in southern Alberta. Emergence, stand count, *Rhizoctonia* stem and stolon canker, black scurf, yield, and tuber quality were assessed. Few differences in date of emergence were noted and the final stand counts were similar regardless of seed piece treatment. Quadris IFAP appeared to be very effective, compared to the check, at reducing early season stem and stolon canker caused by *Rhizoctonia*. Very little black scurf was observed on daughter tubers collected from either portion of the field. As a result, it was difficult to determine the effect of Quadris IFAP on black scurf. Harvest data was very similar for all areas of the field. There was no apparent advantage or disadvantage to using Quadris IFAP on Russet Burbank potatoes with respect to yield or grade.

Awaken product evaluation (sponsored by UAP Canada)

Several fertilizer products were evaluated as in-furrow at planting or foliar applications on Russet Burbank potatoes to determine the best rates and combination of products to enhance yield and potato quality. Emergence was similar between all treatments and no significant difference in the number of stems per plant was observed. No statistically significant differences in yield were measured in 2005. Some trends were observed. Awaken in-furrow alone or in combination with in-furrow Ca did not improve yield relative to the check. However, applications of Awaken in-furrow coupled with a foliar application of 10-16-38 plus Bo and Zn did result in greater total and marketable yield. The greatest total and marketable yield was observed when 10-16-38 was applied as a foliar treatment, but when applied with Bo and Zn resulted in a slight decrease in yield. Few significant differences between treatments were noted with respect to specific gravity, and French fry quality is expected to be similar between treatments. Awaken in-furrow plus foliar 10-16-38 with Bo and Zn and foliar 10-16-38 alone resulted in reasonable gross margins per acre. Providing that growers are equipped to apply such products as part of existing fieldwork operations, these treatments could be expected to improve net returns to producers.

This trial was done at CDCS.

The potato agronomy research program also collaborates with other AAFRD research scientists on projects of interest to the potato industry. In 2005, these included:

Evaluation of early blight *(Alternaria solani)* prediction techniques for southern Alberta

Petiole nutrient (N, P and K) recommendations for Russet Burbank potatoes grown in southern Alberta

Technology Transfer

Information about these projects was provided by the program leader, M. Konschuh, to producers, processors, and other industry staff at industry meetings, field days and individually as requested. The results of research projects were presented at industry meetings and through direct contact. Lori Delanoy, AAFRD extension agronomist, handles extension responsibilities for the potato industry not specific to research projects.

Special Crops Program

M. Bandara, Program Leader
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The special crops program at CDCS is primarily responsible for the evaluation, introduction, and development of new crops for southern Alberta through applied and adaptive research projects. Some study projects are conducted in collaboration with other research programs at CDCS, other divisions of Alberta Agriculture, Food and Rural Development (AAFRD), University of Alberta, Crop Development Centre (CDC) at the University of Saskatchewan (U of S), Agriculture and Agri-Food Canada, Applied Research Associations and industry partners. Different funding sources such as Agriculture Funding Consortium, regional variety testing programs and also several industry partners, provide the financial support for the program.

Research Projects

Pulse Crop Studies

Chickpea and lentil crop improvement project

In 2001, a five-year crop improvement project for chickpeas and lentils was initiated at CDCS, Brooks in collaboration with CDC and the U of S Saskatoon, where F_1 and F_2 generations of both crop species are raised. The main objective of this project was to develop new chickpea and lentil cultivars for southern Alberta under dryland conditions, with specific selection criteria of high seed yield, early flowering, early and uniform maturity, resistance to common foliar and root diseases, and desired market traits. Lentil and chickpea ($F_{2:3}$ generation) seeds were acquired from CDC, and seeds of $F_{2:4}$, $F_{2:5}$, $F_{2:6}$ and $F_{2:7}$ lines were selected from early generations grown under field conditions in southern Alberta in previous years. These seed categories were all planted in early May 2005 for further evaluation and selection.

From the two lentil trials 20 lentil lines from Test 1, and 21 lentil lines from Test 2, were selected for further evaluation in 2006. Two separate trials were established, using 21 $F_{2:5}$ red lentil and 3 recommended cultivars (Test 1), and 16 $F_{2:5}$ green lentil and 2 recommended cultivars (Test 2), at 3 sites (CDCS, Bow Island Substation {BISS} and Bow Island grower's site).

On average, crop maturity of red lentil varied from 91 days (2269-7) to 99 days (CDC Redberry) and seed yield varied from 1407 kg/ha (CDC Redwing) to 3187 kg/ha (2271-5). In the green lentil trial, on average, crop maturity varied from 92 days (2342-12) to 97 days (2509-1) and seed yield varied from 1803 kg/ha (2423-1) to 2602 kg/ha (CDC Viceroy). Based on crop growth and other desirable traits, 11 red and 7 green lentil lines were selected for further evaluation in 2006.

Results of an another trial established using 25 $F_{2:5}$ and 3 $F_{2:6}$ lines, 2 recommended cultivars of large green lentil with 2 replicates at BISS, revealed that crop maturity ranged from 86 (1915-1) to 99 days (1956-2, 1434-3 and 1444-1) and seed yields ranged from 852 kg/ha (1915-1) to 2607 kg/ha (1423-3). Based on performance, 10 large green lentil lines were selected for further evaluation in 2006.

Results of the $F_{2:6}$ red lentil study (Test 1) revealed that, on average, crop maturity ranged from 93 days (1967S-5) to 101 days (CDC Redberry) and seed yield ranged from 2119 kg/ha (1900-2) to 3237 kg/ha (CDC Redberry). Based on line performance, 9 lines were selected for further evaluation in 2006.

In the $F_{2:6}$ small green lentil line test (Test 2), crop maturity varied from 91 days (1887T-9 and 1888T-3) to 101 days (CDC Plato) and seed yield varied from 1949 kg/ha (1887T-16) to 3190 kg/ha (CDC Viceroy). Based on the line performance, 6 lines were selected for further evaluation in 2006.

In addition, the test with small green lentil trials was established at 5 sites in Saskatchewan (Kyle, Goodale, Rosethern, Saskatoon and Davidson). Seed yields of that study varied from 1599 kg/ha (1984S-4) to 2124 kg/ha (CDC Viceroy). Results of the advanced yield trail established using 5 $F_{2:7}$ lines and 2 recommended cultivars of red lentils at 3 sites (CDCS, BISS and Bow Island grower's site) revealed, on average, crop maturity varied from 95 days (1405T-7) to 98 days (Redberry) and seed yield ranged from 2157 kg/ha (1405T-7) to 2771 kg/ha (Redberry). Based on crop performance, 4 red lentil lines were selected for further evaluation in 2006.

Seventy-three $F_{2:4}$ lines and 11 recommended cultivars of desi and kabuli chickpeas were grown in standard plots at CDCS and BISS, with one replicate at each site. All the plots were harvested at both sites and a total of 40 lines were selected based on desirable growth habits, seed weight, seed yield and crop maturity. In addition, 14 $F_{2:5}$ lines (11 desi and 3 kabuli) and 4 recommended cultivars of desi and kabuli chickpeas were grown in standard plots at CDCS and BISS with 2 replicates at each location.

Based on crop growth and other desirable traits, a total of 12 (9 desi and 3 kabuli) lines were selected for further evaluation. A total of 16 lines of $F_{2:6}$ and $F_{2:7}$ (9 desi and 7 kabuli) and 6 recommended cultivars were grown in standard plots at 3 sites in Alberta (CDCS, BISS and Bow Island grower's site) and 4 sites in Saskatchewan (Kyle, Goodale, Elrose and Davidson) with 2 replicates at each site. Based on crop growth and other desirable traits, 11 lines (5 desi and 6 kabuli) were selected. All these selected lines will be evaluated in advanced or elite trials in 2006. However, some promising chickpea lines will be included in the pre-breeder seed production program.

Impact of size of the seed planted, on crop phenology and seed yield of kabuli chickpeas

Smaller seed category of kabuli chickpeas can be used for planting without affecting seed yield or the seed size profile of the resulting crop

The size of the seeds planted has been shown to have a significant impact on seedling establishment and vigor, and crop growth of several small-seeded field crops such as canola, mustard, coriander and carrot. Conversely, other studies have revealed that the seed size had no significant impact on plant growth, development and seed yield of large-seeded crops such as chickpeas. Two studies were conducted at CDCS to examine the effect of size of seeds planted, on seedling growth, seed yield and seed size profile of the resulting crop have indicated that seed size planted, has no significant impact on plant growth, seed yield components and seed yield. These observations suggest that smaller seed category of kabuli chickpeas can be used for planting without affecting seed yield or the seed size profile of the resulting crop. Moreover, the use of a smaller seed category at a higher seeding rate (1.4 x recommended seeding rate) had no significant effect on seed yield. This assumes the reduction in seed size is not due to disease infected or immature seed. If a smaller seed category is used for planting purposes, the grower could reduce seed cost due to a reduced seeding rate and transportation cost. At the same time, the larger seed portion of the crop can be sold at a premium for human consumption.

Impact of seeding date on size and variation of seed of the resulting crop and impact of seed size on seedling emergence and vigour of chickpea (*Cicer arietinum*) cultivars CDC Chico and Myles

The cultivation of a pulse crop in rotation with cereals is an effective mean to improve soil quality. The many advantages extend beyond the years they are grown. Commercial production of chickpeas (*Cicer arietinum*) started in Canada in 1995. Several agronomic studies are being conducted on the semi-arid prairies to enhance the crop productivity and product quality of chickpeas. A study was conducted to evaluate the impact of seeding date (fall-seeded and early/late spring-seeded) on size and variation of the seed of the resulting crop and the impact of seed size on seedling emergence and vigour of small-seeded kabuli cultivar CDC Chico and desi chickpea cultivar Myles. Randomly selected seeds of CDC Chico and Myles, derived from four different seeding treatments (fall-seeded without seed coat treatment, fall-seeded with seed coat treatment, early spring-seeded and later spring-seeded) were used to determine the individual seed weight. Seeds were planted individually into plug trays and were placed in a greenhouse. Seedling emergence and growth were observed. Seedlings were harvested at 4 weeks after seeding and plant height, aboveground and root biomass dry weight were determined.

Results showed on average, the Chico cultivar produced heavier seeds, higher plants, heavier plant biomass, and had an earlier seedling emergence than the Myles cultivar. Seeds derived from fall-seeded Myles were more uniform than CDC Chico. The seeding date had no significant impact on plant growth and variation for CDC Chico. There was no strong evidence that seed weight had a significant impact on seedling emergence and vigour.

Previous studies have shown that the size of the seed planted had no significant impact on seed yield of large-seeded chickpeas. The lack of significant impact of weight of the seeds planted on seed yield suggests that a lighter seed category can be used as a planting material without significantly affecting the yield of the resulting crop. Growers could sell heavier portions at a premium price and use lighter seed for seeding.

Regional cultivar/Coop evaluations

Newly recommended cultivars and promising lines of chickpeas, dry beans, field peas, lentils and soybean received from various pulse breeding programs are evaluated under growing conditions in southern Alberta, to select the most promising cultivars for the region.

The emphasis of the dry bean cultivar testing is on yield performance, early maturity, and the architecture of a dry bean plant that allows for narrow row configurations, direct combining and consequently, an expansion of dry bean production to areas in Alberta. The majority of bean cultivars/lines for this evaluation were received from the dry bean crop improvement programs at AAFC - Lethbridge and the CDC at the U of S.

In late May 2005, five field studies were established at BISS, using various dry bean lines/varieties belonging to different commercial classes black, great northern, pink, pinto and small red, (1 coop, 1 narrow row and 1 wide row under irrigation) and at CDCS (1 narrow row and 1 wide row under irrigation). Performance of most bean cultivars/lines was site-specific. Among the cultivars evaluated, CDC Minto (pinto), CDC Expresso (black), AC Black Violet (black), AC Scarlet (small red), CDC 95346 (pink) and AC Early Rose (pink) produced higher seed yields than respective check cultivars.

Two field pea cultivar evaluation studies were conducted at CDCS and BISS, to evaluate varieties/lines for regional adaptation. At both test sites, under rain-fed conditions, 6 green pea cultivars/lines produced seed yields ranging from 4569 to 5719 kg/ha in Brooks and 3031 to 4087 kg/ha at Bow Island. Among the 12 yellow field pea cultivar/lines evaluated, SW Marquee (3892 kg/ha) produced the lowest and Carrera (5792 kg/ha) produced the highest seed yield at Brooks, and CDC Handel (3029 kg/ha) the lowest and CDC 653-8 (4135 kg/ha) produced the highest seed yield at Bow Island.

One study was conducted with 13 chickpea cultivars at CDCS. Seed yield ranged from 3515 kg/ha for CDC Diva to 6288 kg/ha for CDC Cabri. Two separate trials were conducted with 9 early maturing lentil cultivars and 9 late maturing cultivars at CDCS. Seed yield for early maturing cultivars ranged from 1978 kg/ha for CDC Blaze to 2894 kg/ha for CDC Milestone. Among the late maturing cultivars, Laird produced the lowest seed yield (1784 kg/ha), whereas CDC Richlea produced the highest seed yield (2591 kg/ha).

Soybean tests were established at BISS under rain-fed and irrigated conditions using 16 cultivars received from the oilseed breeding program at AAFC - Ottawa. Poor seedling emergence caused by silt deposition as a result of severe rainfall, the non-irrigated (rain-fed) soybean test was abandoned. Among the cultivars tested in the irrigated test, soybean cultivars AC Orford (2071 kg/ha) and Prembina (2011 kg/ha) produced significantly higher seed yield than the standard cultivar, Gentleman (1640 kg/ha).

Over 65 cultivars/lines of silage and grain corn were established for regional adaptation. Both silage and grain corn performed very well under both Bow Island and Brooks' growing conditions.

Evaluation of new pulse crop species

Seed of unnamed and named lines of mung bean (*Vigna radiata* L. Wilczek), black gram (*Vigna mungo* L. Hepper.), moth bean (*Vigna aconitifolia*) and pigeon pea (*Cajanus cajan* L. Millisp) were planted in the research field at

CDCS in early June 2005. Crop maturity was challenged by a cool and wet growing season so that none of the crop species were harvested.

Medicinal botanical studies

Evaluation of chicory (*Cichorium intybus* L.) in Alberta for local processing of high quality inulin, functional food ingredient

Chicory (*Cichorium intybus*) is a perennial root crop belonging to the *Asteraceae* family. It is native to Europe, central Russia and western Asia, and cultivated widely through Europe in early times. Chicory root may be roasted and ground to produce a coffee substitute/adulterant (chicory coffee), or harvested, stored, and forced to produce a high-value vegetable.

Chicory roots contain high levels of inulin and fructo-oligosaccharides. Inulin is a long-chain fructan molecule. Fructans are non-reducing, water-soluble carbohydrates formed in higher plants composed of fructosyl units, but usually contain one terminal glucose moiety per molecule. They occur as linear, branched, or less frequently, cyclic molecules. Natural β-fructans have a degree of polymerization (DP) ranging from 2 to 55, or more. Lower mass fructans (DP ≤ 10) are called fructo-oligosaccharides (FOS) or oligofructose, while higher mass polymers are known as a 'high performance' type inulin. The 'high performance' type of inulin has an average DP of 25 and a molecular distribution ranging from 11 to 60.

Inulin and FOS have been shown to act in a similar way as dietary fiber products, and are also lower in calories than sucrose. Inulin and FOS have prebiotic effects; they enhance growth of lactobacillus bifidobacteria in the human intestine and can improve the balance of the beneficial bacteria in the bowel. Humans cannot digest inulin and fructo-oligosaccharides, as they do not have the necessary enzymes available in their digestive system. Inulin and fructo-oligosaccharides are used as a food ingredient in low-fat, calorie-reduced products and can also act as a natural sugar replacement for diabetics.

Based on the local current demand, it is estimated that inulin production will require up to 4,000 ha of chicory crop to be grown in southern Alberta. This would be a new, high-value crop for Alberta, providing additional options for southern Alberta farmers and further lessening the dependence on grains and other low-value crops. Moreover, much of the existing planting equipment could be used for growing chicory and processing chicory roots for inulin. However, chicory is a relatively new crop to North America, thus, information on cultivars with high-quality inulin content and cultural practices for root production on the Canadian Prairies, is lacking. The 3-year study project was initiated in 2005 with the following objectives:

- To determine the impact of the growing environment on root and inulin production in chicory.
- To select promising chicory cultivar(s) for higher root production and inulin production.
- To determine the seeding time for higher root and inulin production.
- To examine the impact of storage conditions on quality of inulin (length of the inulin chain) of chicory crude extract.

Five European chicory cultivars were seeded on two different dates (mid April and early May) at two test sites, BISS and Taber. The crops were successfully

grown under irrigation and were harvested in late September. Results indicated, that on average, the seeding date had no significant impact on root yield when expressed on dry weight basis, at both test sites. Depending upon the cultivar, root yield varied from 36.7- 45.9 FW t/ha or 9.8-11.8 DW t/ha at BISS and from 41.0 to 43.1 FW t/ha or 9.5-13.7 DW t/ha at Taber. Total fructan yield of chicory roots did not change due to seeding date or among cultivars used in this study at both test sites. The study on the effect of storage condition on the chain length of inulin in the crude root extract is in progress, and results will be available in three months. This information, however, suggests that chicory can be successfully grown for root production in southern Alberta.

Chicory can be successfully grown for root production in southern Alberta.

Rosemary nutraceutical industry feasibility study

Rosemary (*Rosmarinus officinalis* L.) is a native shrub of southern Europe, Morocco and Tunisia, belonging to the *Labiateae* family. Rosemary is used as a culinary herb with meat, vegetables and soups. Numerous studies have indicated that rosemary leaf extract contains diterpenoid compounds that possess antioxidant properties. Norac Technologies Inc., Edmonton, Alberta, extracts antioxidants such as carnosic acid, carnosol and methoxy carnosic acid from imported rosemary. The imported rosemary has inconsistent quality as a result Norac is looking for alternative sources of high-quality rosemary leaves, possibly from local producers. However, information on production of rosemary leaves at commercial scale on the Prairies is not available.

The main objectives of this project were to examine the possibility of growing rosemary as an annual crop under field conditions in southern Alberta, to select promising cultivar(s) with higher leaf biomass productivity and higher content of selected diterpenoid compounds (antioxidants), and to evaluate the impact of soil nitrogen content, plant population density, nursery period of rooted stem cutting and first and killing frosts on aboveground biomass productivity and antioxidant content.

Rosemary can be successfully grown as an annual crop under the field conditions in southern Alberta. The results indicated that (a) under experimental conditions, depending upon the cultivar, total aboveground biomass yield with a range of 6870-8915 kg/ha' and leaf yield with a range of 3420-4508 kg/ha can be harvested; (b) Rex, an unnamed cultivar and Primery Blue are the most promising cultivars in terms of total and leaf biomass production; (c) first frost had no adverse impact on total phenolic compound yield of rosemary, but killing frost reduced the carnosic acid content in Rex only; (d) for the highest phenolic compound productivity, rosemary should be grown at a plant population of 250,000 plants/ha; (e) soil N content of 100 kg NO_3-N/ha within a depth of 30 cm is sufficient for maximum leaf production of rosemary. Additional application of nitrogen has no impact on either crop productivity or phenolic compound yield of rosemary. However, further studies should be conducted to determine the optimum nursery period for rooted stem cuttings, to minimize the nursery cost and also to initiate a collaborative project with Norac Technologies Inc., and prospective growers to produce rosemary for processing of antioxidant in Alberta.

Micro-propagation of EMS-induced mutants and promising lines of non-mutant of Echinacea (*Echinacea angustifolia, E. pallida* and *E purpurea*)

Echinacea (*Echinacea angustifolia*) is the most extensively grown medicinal herb in Alberta. The root yield of field-grown Echinacea in Alberta varies from 300-900 kg/ha, even though the yield potential of the crop can be as high as 5500 DW kg/ha. Moreover, the echinacoside content varies from 0.6% to 2.1%. Aster Yellows, caused by phytoplasma, is the most common and destructive disease in Echinacea. It reduces the root productivity as well as the over-wintering ability of the plant. Very little attention has been given towards the crop improvement activities in Echinacea. Consequently, Echinacea varieties with Aster Yellows resistance are not available in North America. Over the past 6 years, an Ethyl methane sulphonate (EMS)-induced mutation breeding project on *E. angustifolia, E. pallida* and *E. purperea* was initiated and carried out to develop Aster Yellows resistant *Echinacea* cultivars with high active ingredient content at CDCS. The main goal of this study was to develop Echinacea lines with Aster Yellows resistance and high medicinal qualities. The micro-propagation project was funded through the New Initiatives Funds. Individual plants with field resistance to Aster Yellows were selected over several years. In addition, seed samples from two sources of Echinacea crops with high bioactive ingredients, were planted in a greenhouse. Despite the fact that surface sterilization of the field-grown Echinacea leaves was a challenging process, over 200 plantlets sere successfully propagated through tissue culture techniques. These plantlets are in different growing stages (organogenesis, root proliferation, greenhouse-ready stage and greenhouse stage).

It may take another 4-5 months for tissue culture plantlets to reach the size necessary for transferring to a greenhouse for root production. After growing these plants for 2 months in a greenhouse, roots will be analyzed for bioactive compounds and also for resistance to Aster Yellows disease. This project will be conducted in collaboration with Dr. Ron Howard (Plant Pathologist, CDCS) and Scott Meers (Entomologist, CDCS).

Fenugreek advanced line evaluation for seed yield and galactomannan content

Fenugreek (*Trigonella foenum-graecum* L.) is an annual plant species belonging to the *Fabaceae* family. It has great potential for food, pharmaceutical and industrial uses, and also as a forage crop. Traditional oral use of fenugreek had been for the treatment of decreased appetite, upset stomach, bronchitis, fevers, sore throats, and in expelling intestinal worms.

About 30% of the reserve food material in the fenugreek seed is galactomannan, which deposits in the endosperm. Galactomannan is a polysaccharide made of galactose combined with mannan, a high molecular compound of mannose. Mannose cannot be digested and it is not nutritious. Galactomannan has a property, which increases viscosity when dissolved in water. The galactomannan fraction of fenugreek endosperm is often referred to as 'gum'. Many of the dietary effects and uses of fenugreek are related to the presence of galactomannan in the endosperm. Clinical studies have shown that galactomannan in the diet decreased the concentrations of cholesterol in both liver and blood plasma, and also decreased the synthesis of cholesterol in the liver.

The current fenugreek lines available in Canada have been selected for early crop maturity and higher seed yield. The main goal of this study is to select fenugreek line(s) with a higher galactomannan content for a source of functional food ingredients. Over 15 fenugreek lines were evaluated for crop growth, crop maturity and seed yield. Several early maturity and higher seed yields lines of fenugreek with were selected. Due to limitation of funding, only a few fenugreek lines were evaluated for galactomannan content. Results indicated that those tested lines are significantly different in galactomannan content. A project proposal is being developed for a comprehensive evaluation of fenugreek lines for galactomannan content.

Evaluation of possibilities of producing high quality fibrous root of American ginseng (*Panax quinquefolius*) under hydroponics and bioreactor conditions

American ginseng is distributed throughout the Eastern temperate forest region of North America. It is a slow growing plant, which requires an average of 4 years before the roots reach a marketable size. In general, the crop is seeded during the fall season to produce 1-year-old seedlings the following year. Because of the absence of improved varieties, cultivated ginseng plants are genetically and morphologically heterogeneous. Consequently, variations in root yield and quality, among and within plant populations, are frequently evident. Ginseng is primarily grown for taproots, which contain high levels of triterpenoid saponins (ginsenosides). Ginsenosides are the compounds responsible for reputed medicinal and therapeutic properties of ginseng. Ginseng saponins yield aglycone (sapogenin) and a sugar moiety upon acid hydrolysis. The major sapogenins reported in *Panax* species are dammarane triterpenoids and oleanolic acid. A major division in sapogenin component occurs among morphological types. Species with fleshy taproot contain saponins largely of the dammarane type, while primitive species with a well-developed rhizome but fibrous root system contain a larger percentage of oleanolic acid type saponins.

Panax species have also been grouped according to root and rhizome characteristics. The primary root of all species of *Panax* is fleshy, although not all are persistent. The taproot degenerates and adventitious roots form along the rhizome in some species. Species with creeping rhizomes and a fibrous root system are considered primitive taxa. Those species with a fleshy root and erect rhizome include *Panax quinaquefolium, Panax ginseng, Panax trifolium* and *Panax pseudoginseng*.

There have been a number of human studies, looking at the effects of ginseng on athletic performance. Results have not been consistent, however, the interest of using ginseng plant parts, particularly adventitious roots, which contain relatively higher levels of specific bioactive compounds such as polysaccharides and certain saponins, as a source for performance enhancing products for athletics, remains consistently high. Thus, the industry is looking for various means of enhancing the adventitious root production in ginseng.

A hydroponics production system offers an efficient way to produce crops for the pharmaceutical industry. This technology is based on latest achievements in plant physiology and production. The system is an extension of recycling technology where nutrients are supplied through a solution to the roots. This ensures optimal supply of oxygen and nutrients to the plant roots, leading to the fastest crop production rate. The technology is especially well suited for production of roots, as the produced plant material is very clean and very

easy to harvest. Thus, this study project is being conducted using three new formulations developed by Precise Hydroponics Ltd, Edmonton, in collaboration with the U of A, with the following objectives.

- To examine the effect of three compounds applied with nutrient solution, on plant growth and root production of hydroponically- and bioreactor-grown ginseng.
- To examine the effect of three compounds applied with nutrient solution, on adventitious root production in solution from callus.
- Develop protocols to optimize plant mineral nutrition in the hydroponics system for adventitious root production in ginseng.

Preliminary results will be available in August 2006.

Technology Transfer

Program staff continued to answer numerous inquiries on the production of special crops, particularly on herb, spice and essential oil crops. Several field days and workshops were organized and research information was contributed on special crops to producer newsletters and the news media. Test plots of various special crops, including pulse crops and medicinal herbs at CDCS and Bow Island, were visited by a large number of interested individuals and groups. Extension staff and other interested parties were provided with planting materials for demonstration and field testing to assist herb, essential oil and spice producers in evaluating new crops and developing agronomic practices.

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Meteorological Report

N.G. Seymour

The Alberta Agriculture, Food and Rural Development's Crop Diversification Centre South (CDCS) operates two automated weather stations; one at the Centre southeast of Brooks and another at the sub-station southwest of Bow Island.

Brooks (CDCS)

Precipitation is measured with two instruments at the Brooks station. The Tipping Bucket Rain Gauge (TBRG) very accurate in reading rainfall to 0.2 mm is not reliable for recording snowfall. The Fischer-Porter Weighing Gauge (F&P) provides an accurate reading for snowfall equivalent. 2005 was an extremely wet year for the Brooks area with over 180mm above the thirty year average. 220mm of rain fell in June alone as well as well above average precipitation in August and September.

The final spring frost of 2005 occurred on May 12

(-0.5C). The first autumn frost was –1.6C on September 24, giving a total of 134 frost-free days in 2004. This is 18 days more than the 30-year average (1951-80) of 116 frost-free days (May 21 to September 15). On August 13 the minimum temperature went down to 0.8C which may have produced frost in some low lying areas.

Brooks (CDCS) Weather Data

	Temperatures (°C)								Precipitation (mm)		
	Extremes		Average				Means		2005		1971-2000
	Min	Max	Max	30 yr av	Min	30 yr av	2005	30 yr av	TBRG	F&P	30 yr av
January	9.6	-37.2	-6.6	-5.6	-18.5	-17.0	-12.6	-11.3	n/a	6.7	14.7
February	16.8	-21.2	4.8	-2.7	-10.9	-17.0	-12.6	-8.4	n/a	1.4	12.2
March	20.6	-18.4	8.0	3.7	-6.6	-14.1	-3.0	-2.1	n/a	5.0	19.5
April	25.5	-9.0	14.2	12.7	-1.6	-7.8	0.7	5.5	14.6	13.6	27.9
May	26.3	-9.8	19.1	18.9	3.3	-1.7	6.3	11.6	22.2	18.5	44.1
June	30.4	4.3	19.8	23.1	9.0	4.2	11.2	16.0	227.8	219.4	58.8
July	34.3	5.7	25.6	25.7	10.9	8.8	14.4	18.3	42.0	41.7	41.7
August	33.9	0.8	23.0	25.0	8.2	10.9	18.2	17.4	87.2	86.4	39.3
September	28.0	-1.7	18.5	18.8	4.3	9.7	15.6	11.5	97.0	101.3	39.4
October	22.8	-5.7	14.1	13.6	-0.8	4.2	11.4	6.3	30.6	26.4	17.0
November	21.1	-16.8	6.8	1.9	-5.6	-1.1	6.7	-4.0	n/a	6.3	14.7
December	15.6	-28.2	0.0	-4.2	-10.3	-9.7	0.6	-9.9	n/a	4.1	18.9
Average	23.7	-11.4	12.3	10.9	-1.6	-2.4	5.4	4.2	Tot. n/a	530.8	348

Bow Island (Sub-station)

The last recorded frost was –0.2°C on May 12 and the first autumn frost (-2.2C) occurred on September 22, for a total of 132 frost-free days in 2005, seven days more than the 30-year average (1951-80) growing season at Bow Island of 125 days (May 17 to September 20).

The precipitation recorded during the summer months indicates much higher than average moisture for the growing season in Bow Island except for May and July which had very little precipitation. It is important to note that precipitation is only measured with a tipping Bucket Rain Gage which is unreliable during the winter months.

2005 Bow Island Weather Data

	Temperatures (°C)								Precipitation (mm)		
	Extremes		Average				Means		2005		1971-2000
	Min	Max	Max	30 yr av	Min	30 yr av	2005	30 yr av	TBRG		30 yr av
January	14.8	-33.0	-4.0	-5.2	-15.7	-15.9	-9.8	-10.6		3.8	18.6
February	19.0	-17.5	6.5	-0.9	-9.3	-11.7	-1.4	-6.3		0.3	11.3
March	21.4	-20.3	8.0	4.7	-5.8	-6.6	1.1	-0.9		12.7	13.1
April	25.6	-7.7	14.4	12.5	-0.4	0.2	7.0	6.6		15.0	34.2
May	26.2	-9.1	19.1	19.2	3.5	5.5	11.3	12.4		8.1	44.9
June	32.7	5.6	20.7	24.4	9.3	10.7	15.0	17.6		151.1	69.8
July	34.2	6.8	27.3	27.6	11.0	12.1	19.1	19.7		0.3	30.9
August	33.7	2.7	24.5	27.1	9.1	11.9	16.8	19.6		48.8	32.4
September	29.7	-2.2	18.6	20.2	5.3	5.6	11.9	12.9		62.2	30.4
October	23.6	-3.5	14.9	15.0	1.4	0.5	8.2	7.6		23.4	12.3
November	19.8	-21.7	8.3	4.7	-4.2	-6.6	2.0	-1.0	0.0		12.8
December	16.3	-28.0	0.3	-2.8	-10.3	-13.0	-5.0	-7.9	.3		19.0
Average	24.8	-10.7	13.2	12.2	-0.5	-0.6	6.4	5.8	Tot.	326.0	330

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Agronomy
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A. Middleton

Entmology
S. Meers

Fruit & Vegetable Research
C. Neeser, Ph.D.
T. Pheh, Dipl. Ag.
M. Webber

Grass Seed & Forage
H. Najda,, B.Sc., M.P.M., P.Ag.
A Kruger, Dipl. Ag.

Greenhouse Crops
N.A. Savidov, Ph.D.
P. Coté, Dipl. Grnhse Tech.
V. Bansal
N. Mohammed
S. Chambo
L. Kalinina-Staniek

Nursery Crops
C.L. Murray, B.Sc. (Ag.), Ph.D.
N.G. Seymour, Applied Degree Hort.
Sara Williams

Plant Pathology
R. J. Howard, B.S.A., M.Sc., Ph.D., P.Ag
S.L.I Lisowski, Dipl. R.M.T.
D.A. Burke, B.Sc.
D. Slomp
J.A. Hughes
M. Harding, Ph.D

Potato Agronomy
M.N. Konschuh, B.Sc., Ph.D
S. Dalpé, B.Sc. Forestry

Potato Extension
L. Delanoy, B.Sc., CCA

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F. Scharf, B.A., B.A.S
J. Webber
S. Pow
J. Tokuda
V. Catinot
J. Lecombe

Support
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S. Jangula, Dipl Hort., Dipl Composting Tech., P.A. Psyc. (Hons)
A. Moeller
M. Tanigami-Bunney
R. Williams

Marketing
L. Melvill, P.Ag.

Ag. Info Centre
T. Egeland, Support

Agri-Business Expansion
Gordon Frank, B.Sc. , M.Ag., P. Ag.

Rural Business and Diversification
L.G. Hausher, B.Sc. (Ag.) Fruit Crops

Food Science
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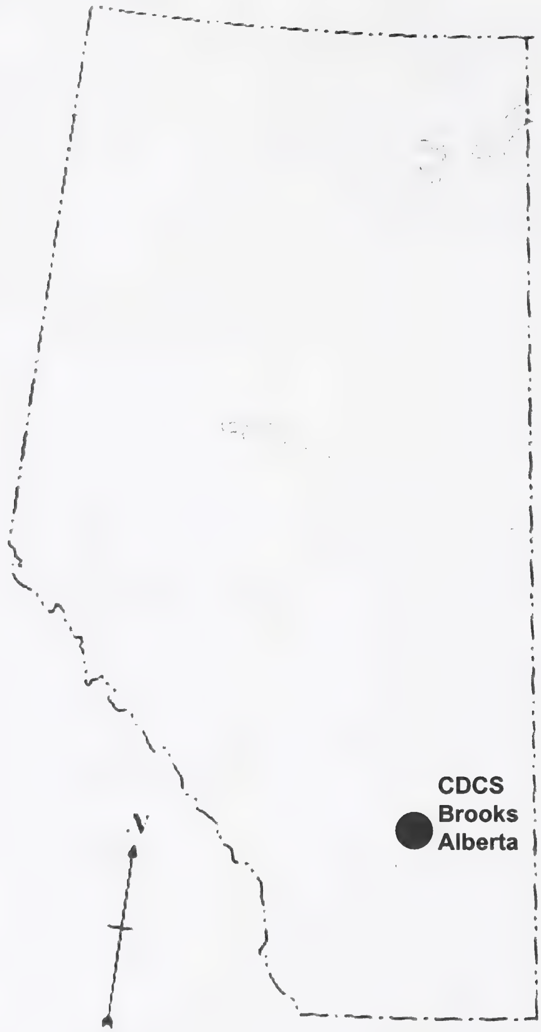
C. Dykstra
M. Hansen, B.Sc. (CE)
Jana Robertson, B.Sc., P. Ag.

Glossary

AAFC	Agriculture and Agri-Food Canada
AAFRD	Alberta Agriculture, Food and Rural Development
AARI	Alberta Agriculture Research Institute
AFFPA	Alberta Farm Fresh Producers Association
ARC	Alberta Research Council, Vegreville, AB
CDCN	Crop Diversification Centre North, Edmonton, AB
CDCS	Crop Diversification Centre South, Brooks, AB
GPS	Global Positioning System
MII	Matching Investment Initiative
U of A	University of Alberta
U of S	University of Saskatchewan

CDCS Location



Crop Diversification Centre South Quick Facts

•surrounded by semi-arid short grass prairie
•site is 127 hectares (316 acres)
•winter temperatures as cold as -40°C (-40°F), but warm west winds (chinooks) can cause the temperature to rise 20 degrees in a few hours
•summer temperatures can reach 39°C (102°F)
•annual precipitation average 300 mm (12 inches), half can be rain in the growing season
•annual average 2,400 sunshine hours
•average growing season is 137 days